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COASTAL ZONE INFORMATION CENTER

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Department of Natural Resources

Division of Geological and Geophysical Surveys

AREAS OF PARTICULAR CONCERN FOR GEOLOGIC REASONS IN THE ALASKAN COASTAL ZONE

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October 1977

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ILLUSTRATIONS

ERRATA SHEET

Page ii: Line 3, add after "subaqueous" the word "sliding"

Line 35, should read "Slope-stability map of Anchorage and vicinity, Alaska"
Pagination for plates should be "attached" not "envelope"

Page 3: Line 30, "XIII" should be "XII"

Page 19: Line 12, "Russel" should be "Russell"

Page 20: Should be page 21 and page 21 should be page 20. Once the numbers are corrected, the sequence should then be reversed

Page 25: Line 27, "ficilities" should be "facilities"

Page 33: Line 20, "particualr" should be "particular"

Line 41, "65 miles" should be "105 km"

Page 43: Line 34, add after "materials" the words ", particularly as armor riprap"

INTRODUCTION

The following report identifies areas of particular concern (APC's) for geologic reasons in the coastal zone of Alaska. This report was prepared by personnel of the Division of Geological and Geophysical Surveys for the Coastal Management Office of the state of Alaska, under a reimbursable services agreement. This project was supported in part by federal Coastal Zone Management Development funds (P.L. 92-583, sec. 305) granted to the State of Alaska by the Office of Coastal Zone Management, National Oceanic and Atmospheric Administration, U.S. Department of Commerce. For the purposes of this report, APC's have been interpreted mainly as being those areas along the coastline in which a geologic process presents a significant hazard to life or to property. In particular, this report identifies only areas of particular concern at the statewide level. Many areas which have potentially hazardous geologic conditions were not included here because, in the judgment of the compilers, the potential hazards were of more local or regional concern than of statewide concern.

A hazard is a possible source of peril or danger. Geological hazards are those which arise from the materials of the earth, the changes which the earth has undergone or is undergoing. This report identifies the more significant areas where geological hazards are presently affecting sites in the coastal zone of Alaska. In order to define the specific areas shown herein, no formal definition of "coastal zone" has been employed. Instead, the initial assumption was to consider only areas of present or likely future development immediately adjacent to the coastline. The entire area of a particular hazard which could affect such developments was then defined to the limit of available data. Thus, APC's subject to potential river flooding may extend inland from the coast for several miles. In addition to geologic hazards, a section has been included on mineral and energy potential in the coastal areas (Plate 2). The areas selected as being of particular concern are listed in Table 1, grouped roughly by the type of hazard present at each site. They are presented geographically in the report, starting in the southeast, working clockwise around the coastline (Plate 1).

This report is not a complete record of all the hazards along the coast of Alaska. The coastline of Alaska comprises more than 30,000 miles and is mostly uninhabited. Much of the coast has never been mapped in detail geologically; even where it has been mapped, such maps were often not for the purposes of identifying geological hazards. Thus, there is a paucity of data on the geological processes in the coastal zone. One of the guiding criteria used herein to identify areas of particular concern is the proximity of a geological hazard to human habitation or zones of probable development. A natural geological process only becomes a hazard when it endangers man or his developments. Thus, if there is nobody to be endangered, there is no hazard. However, this does not imply that an area not mentioned in this report is hazard-free.

The areas of particular concern have been defined by two main criteria. First, the geologic hazards identified herein are based on available data; where no data exist, no hazards can be identified. Second, after identifying the potentially hazardous areas, only those areas were defined as APC's which have present development or likely near-future development and which could be adversely affected by the hazards.

A further limitation arises from the fact that only geological hazards of regional consequence were considered. For example, many sections of coastline are susceptible to problems like ground subsidence, avalanching and slumping. However, such occurrences are usually of strictly local significance and are so numerous that to catalog them would be a task beyond the scope of this report. Some hazards, such as those arising from presence within seismically active areas, are incapable of accurate delineation but have been discussed in order to bring attention to their existance. Other hazards, such as all the areas of severe coastal erosion, have not been sufficiently researched or

Table 1: Areas of particular concern grouped by geological hazards.

Waves and Related Subaqueous Sliding
- Lituya Bay
- Yakutat
- Valdez
- Whittier
- Seward and Resurrection Bay
- Lower Cook Inlet (Eastern Coastline)
- Kodiak
- Scotch Cap - West end of Unimak Island
- Shemya Islands

Volcanism

- Anchorage
- Drift River Delta
- Pribilof Islands

Glacier Dammed Lakes and Outburst Floods

- Yakutat Bay - Russell Fiord
- Copper River Delta
- Knik River Outwash Plain
- Drift River Delta

Coastal Erosion and Deposition

- Icy Bay
- Cape Krusenstern to Cape Thompson
- Wainwright and Barrow and Vicinity
- Prudhoe Bay and Vicinity

Iceberg Drift

- Icy Bay
- Columbia Glacier

Other

- Anchorage (Slope Stability)
- Pribilof Islands (Seismicity)

identified in the literature, and cannot be included at this time.

Note: Each section contains a paragraph on general geologic setting. The geology was usually taken from the source listed as a reference. However, the following two maps were also consulted and are useful for defining the general geology of Alaska: Karlstorm, T.N.V., (compiler) and others, 1964, Surficial Geology of Alaska, U.S. Geol. Survey Map I-357; Beikman, H.K., (complier), 1974, Preliminary geologic map of the southeast quadrant of Alaska, U.S. Geol. Survey MF-612.

Seismic Activity and Earthquake Zones

Although data on Alaskan earthquakes are available back to the late 1700's, the earthquake record for the state is generally incomplete. In the past 75 years scientific interest has grown in Alaska as a whole, and one of the principal results has been increasingly accurate seismic records. For example, accurate and complete records of earthquakes less than magnitude 6.0 are available only since about 1963.

The earthquake activity has been concentrated along the Aleutian Islands, coincident with the chain of active volcanos located there, and along the Gulf of Alaska coast. However, the entire Pacific coast of Alaska and the Aleutian Archipelago lie along a particularly active section of the Circum-Pacific seismic belt, which is geologically related to the "Ring of Fire" discussed in the section on vulcanism. In the past 75 years, nine shocks have exceeded magnitude of 8, the largest near Yakutat in 1899 (8.6), the next largest in the Aleutians in 1957 (8.5) and in Prince William Sound in 1964 (8.4 - The Great Alaska Earthquake). About 7% of the annual world-wide seismic energy is released by earthquakes in the Gulf of Alaska - Aleutian region alone.

Figure A is a small scale map of the major earthquakes in Alaska for the period 1899-1974, given in terms of magnitude. Magnitude is a measure of the size of an earthquake as recorded on a seismogram and is roughly related to the energy release at its focus. Figure B is a small scale map with the projected maximum intensity contours in and near Alaska for the period 1786-1974 with actual reported intensities superposed. An earthquake intensity, expressed by the Modified Mercalli Intensity Scale of 1931, is a somewhat subjective measure of the effects on people and man-made structures. Intensity, which is expressed in Roman numerals from I to XIII, is an effective shorthand for describing the maximum effects of a particular earthquake at a specific locality (Table 2).

Figure C is a generalized tectonic map showing selected structural features of south-central Alaska. Included on this map are faults with known recent or historic movement. It is possible that surface breakage could have occurred along faults during other earthquakes in Alaska, but such features easily could have gone undetected if they occurred in the uninhabited areas. Any site should be investigated in detail for faults before development, especially where large, costly structures or structures for permanent human occupation are anticipated. Areas near to the known active faults shown on Fig. C should be treated with particular concern in this respect; structures should not be located across the trace of faults, and design should allow for the effects of lateral and vertical accelerations of structures in the event of earthquakes on the faults.

Near-fault horizontal ground motions have been characterized for design earthquakes along the Trans-Alaska Pipeline corridor. Subject to simplifying assumptions and to the uncertaintainties of limited data, the values of maximum horizontal acceleration are 1.2 a

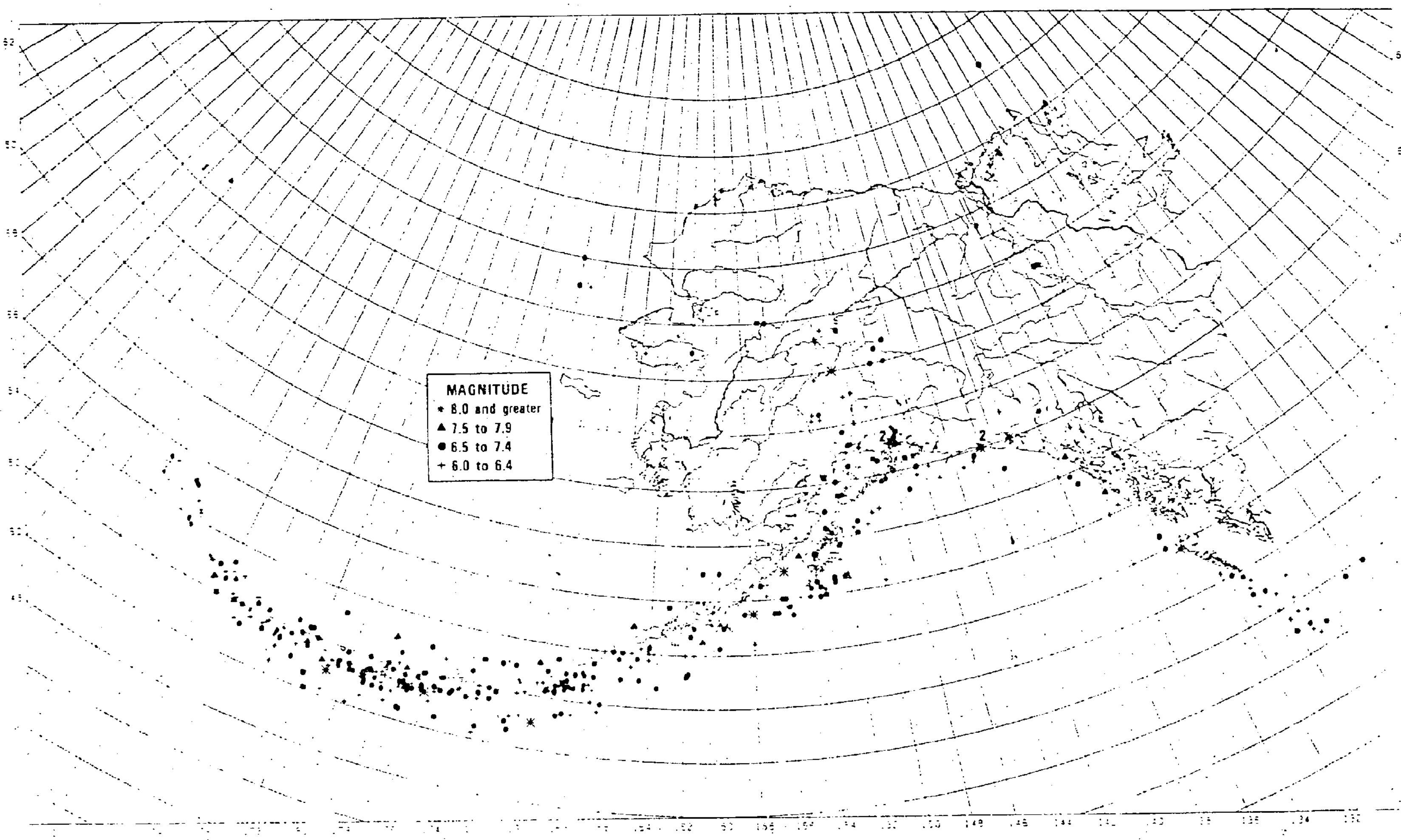


Figure A: Major earthquakes in Alaska (1899-1974). From Page and Lahr (1976).

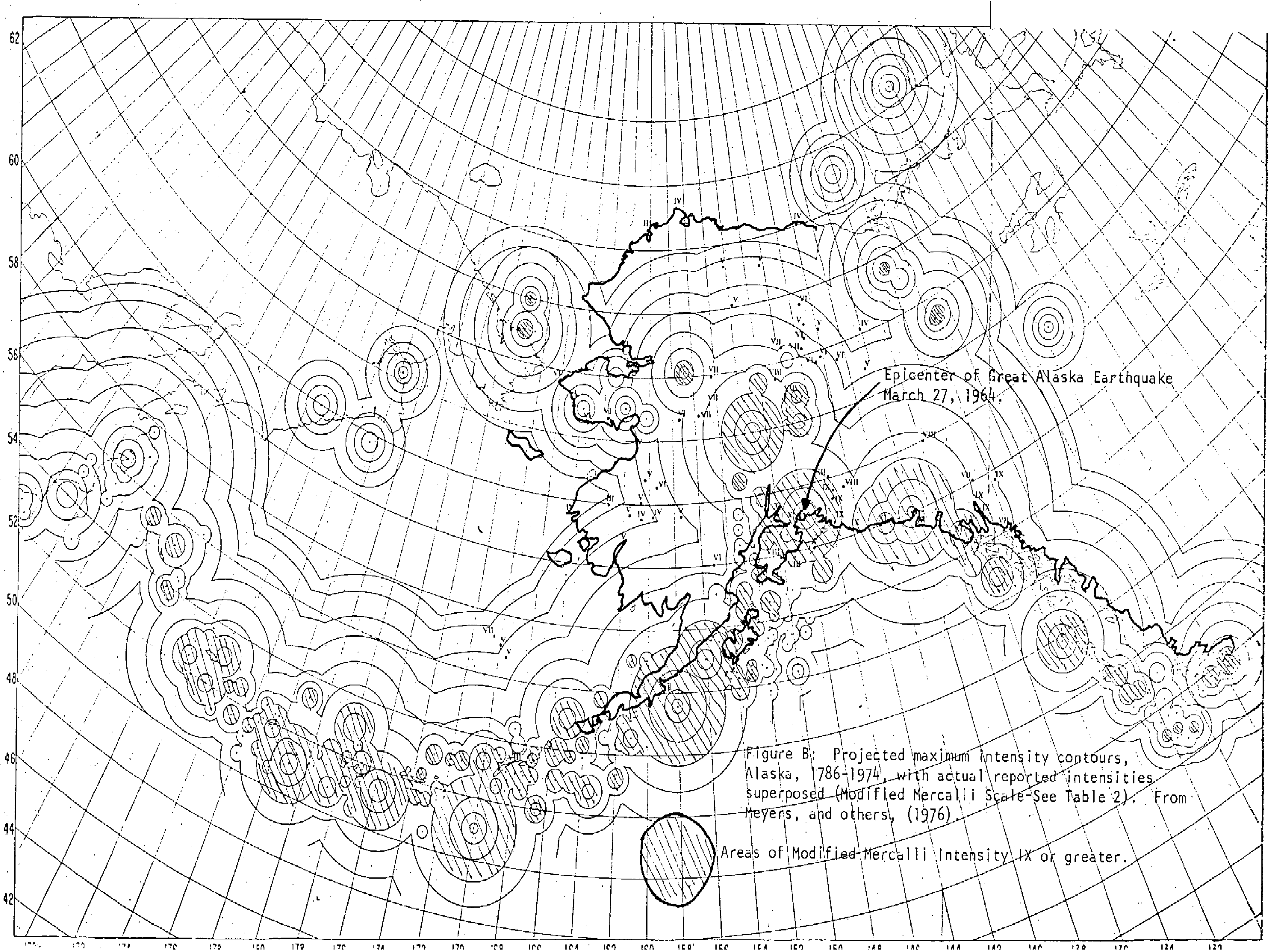


Figure B: Projected maximum intensity contours, Alaska, 1786-1974, with actual reported intensities superposed (Modified Mercalli Scale-See Table 2). From Meyers, and others, (1976).

Areas of Modified-Mercalli Intensity IX or greater.

(ABRIDGED)

I. Not felt except by a very few under specially favorable circumstances. (I Rossi-Forel scale.)

II. Felt only by a few persons at rest, especially on upper floors of buildings. Delicately suspended objects may swing. (I to II Rossi-Forel scale.)

III. Felt quite noticeably indoors, especially on upper floors of buildings, but many people do not recognize it as an earthquake. Standing motorcars may rock slightly. Vibration like passing of truck. Duration estimated. (III Rossi-Forel scale.)

IV. During the day felt indoors by many, outdoors by few. At night some awakened. Dishes, windows, doors disturbed; walls make creaking sound. Sensation like heavy truck striking building. Standing motorcars rocked noticeably. (IV to V Rossi-Forel scale.)

V. Felt by nearly everyone, many awakened. Some dishes, windows, etc., broken; a few instances of cracked plaster; unstable objects overturned. Disturbances of trees, poles, and other tall objects sometimes noticed. Pendulum clocks may stop. (V to VI Rossi-Forel scale.)

VI. Felt by all, many frightened and run outdoors. Some heavy furniture moved; a few instances of fallen plaster or damaged chimneys. Damage slight. (VI to VII Rossi-Forel scale.)

VII. Everybody runs outdoors. Damage negligible in buildings of good design and construction; slight to moderate in well-built ordinary structures; considerable in poorly built or badly designed structures; some chimneys broken. Noticed by persons driving motorcars. (VIII Rossi-Forel scale.)

VIII. Damage slight in specially designed structures; considerable in ordinary substantial buildings with partial collapse; great in poorly built structures. Panel walls thrown out of frame structures. Fall of chimneys, factory stacks, columns, monuments, walls. Heavy furniture overturned. Sand and mud ejected in small amounts. Changes in well water. Persons driving motorcars disturbed. (VIII+ to IX— Rossi-Forel scale.)

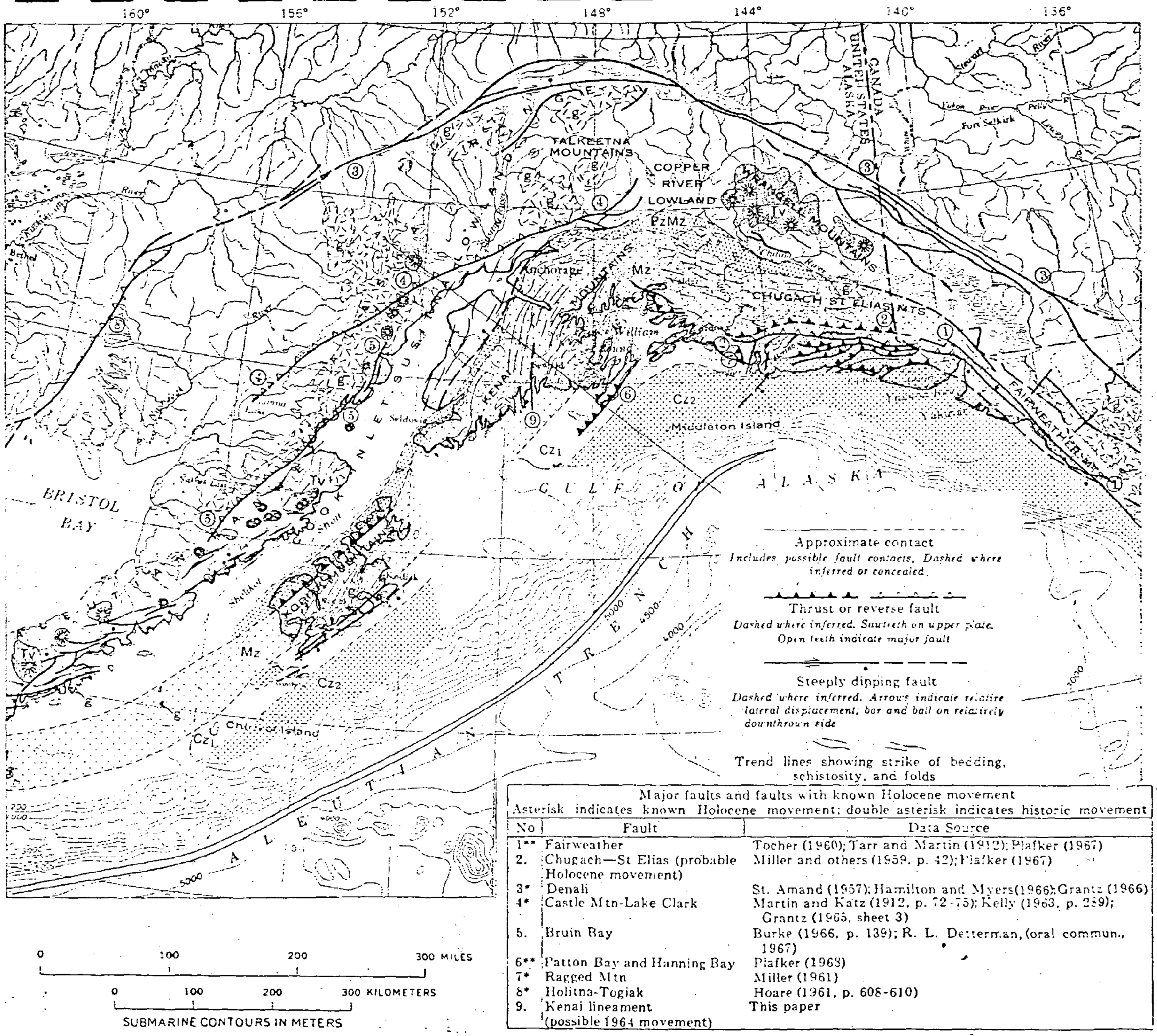
IX. Damage considerable in specially designed structures; well-designed frame structures thrown out of plumb; great in substantial buildings, with partial collapse. Buildings shifted off foundations. Ground cracked conspicuously. Underground pipes broken. (IX+ Rossi-Forel scale.)

X. Some well-built wooden structures destroyed; most masonry and frame structures destroyed with foundations; ground badly cracked. Rails bent. Landslides considerable from riverbanks and steep slopes. Shifted sand and mud. Water splashed (slopped) over banks. (X Rossi-Forel scale.)

XI. Few, if any, (masonry) structures remain standing. Bridges destroyed. Broad fissures in ground. Underground pipelines completely out of service. Earth slumps and land slips in soft ground. Rails bent greatly.

XII. Damage total. Waves seen on ground surfaces. Lines of sight and level distorted. Objects thrown upward into air.

Table 2: Modified Mercalli Intensity Scale of 1931.



Major faults and faults with known Holocene movement
Asterisk indicates known Holocene movement; double asterisk indicates historic movement

No	Fault	Data Source
1**	Fairweather	Tocher (1960); Tarr and Martin (1912); Plafker (1967)
2.	Chugach—St Elias (probable Holocene movement)	Miller and others (1959, p. 42); Plafker (1967)
3*	Denali	St. Amand (1957); Hamilton and Myers (1966); Grantz (1966)
4*	Castle Mtn-Lake Clark	Martin and Katz (1912, p. 72-75); Kelly (1963, p. 289); Grantz (1965, sheet 3)
5.	Bruin Bay	Burke (1966, p. 139); R. L. Detterman, (oral commun., 1967)
6**	Patton Bay and Hanning Bay	Plafker (1968)
7*	Ragged Mtn	Miller (1961)
8*	Holitna-Togiak	Hoare (1961, p. 608-610)
9.	Kenai lineament (possible 1964 movement)	This paper

Figure C: General tectonic map of southcentral Alaska. From Plafker (1969).

1.05 times gravity (that is, 1.2 g and 1.05 g) for magnitude 8.0 and 7.0 earthquakes, respectively. Levels of horizontal acceleration which would be exceeded 10 times in a single earthquake are .7 g and .55 g for magnitude 8.0 and 7.0 events, respectively. The duration of shaking (time between first and last accelerations equal to or greater than .05 g) may strongly influence the extent of damage; values for 8.0 and 7.0 events are 60 seconds and 25 seconds. Peak horizontal acceleration values and duration values decrease with distance from the fault source of the earthquake, beyond some minimum distance which is greater for larger earthquakes (Page and others, 1972).

There are a multitude of problems and geologic hazards which accompany the development of land within a seismically active area. Some of these problems have been the basis for APC's identified in other parts of this report, such as tsunamis and submarine sliding Due to scale limitations, others cannot be covered in this report. For example, hazards which are judged to be of local significance have not been included, even though such hazards can bear significantly on the cost and stability of local man-made works. Such hazards include surface cracking and fracture, local landsliding, surficial subsidence from compaction of unconsolidated sediments, liquifaction of saturated sediments, avalanching and direct vibratory shaking resulting in structural damage. These hazards are largely controlled by local geology and features.

The maps of seismicity and faulting included with this report are of necessity too large to show specific zones of earthquake occurrence. The nature of the hazard is such that the local geology must be investigated in detail to determine the extent of the risk at the specific site in interest. Note that because the southern coast of Alaska is in such a seismically active area, no coastal site in these regions can be considered free of possible damage from a potential earthquake.

Waves and Related Subaqueous Slides

Most major earthquakes that involve vertical tectonic displacements beneath the sea are followed by seismic sea waves, which are also referred to as regional tsunamis. The earthquake of March 27, 1964, The Great Alaska (Prince William Sound) Earthquake, generated one of the largest seismic sea-wave trains of modern times. Waves generated by volcanic activity, such as by Mt. Augustine in 1883, are termed local tsunamis. Sudden violent local waves were the major cause of property damage and casualties in the 1964 earthquake. This sort of wave originates near shore as a result of subaqueous sliding, seiches, subaerial landsliding, tectonic movements or a combination of those phenomena. These local waves affect areas of limited extend and should be distinguished from regional tsunamis. Considerable damage to nearshore facilities can be attributed to the subaqueous sliding which in turn generates destructive local waves.

In Alaska, the completeness of the record of tsunamis and the reliability of such information has depended largely upon cultural development along the coasts. The earlier tsunamis are not well recorded and what little information has been passed down is often fragmental and uncertain. The 1964 earthquake generated a regional tsunami which caused 20 deaths and destruction along the Alaskan coast from Kodiak Island to Kayak Island. Information on that event is voluminous, and the catalog of damage impressive. Because of these factors, this tsunami has provided the main basis for analysis of tsunami hazard along the southern coast of Alaska.

A problem associated with the problem posed by inadequate records is that the appraisal of risks involved on the occasion of a seismic event depends upon a knowledge of the range of the effects of a tsunami which may be expected. Uncertainties are great in Alaska since the record is short and incomplete and the coastal configuration is complex. These variables taken together with the fact that an earthquake which may generate a tsunami could occur nearly any place along the southern coast of Alaska and out into the Aleutian Chain make the prediction of tsunami risk at any particular place uncertain.

It must be emphasized that the areas which have been selected as being of particular concern are those for which data are available and for which a tsunami has resulted in considerable damage, or death. Many uninhabited areas along the coastline are susceptible to tsunami hazards and many of the other populated areas in Alaska, particularly in the Aleutian Chain, have records of tsunamis which have not caused significant damage. For the purposes of this report, a runup height of 2-3 meters has been selected as the dividing line for inclusion of areas, since an analysis of the data indicates that runup heights below this level have not normally resulted in significant damage. Runup heights have been taken from the available literature, and although no uniformity is used, most refer to the height above the existing tide levels at the time of the occurrence. It must be recognized that damages from tsunamis in the identified areas of particular concern and elsewhere could have been more extensive if the tsunami had struck at high tide levels.

While the areas of particular concern discussed in this report are inclusive of the available data, they are not intended necessary to be predictive of areas which will suffer similar damage in the event of another major earthquake such as that in 1964. The areas were selected solely because loss of life or significant property damage occurred at these places in the past, or because recent development activity is occurring and it is possible that similar damage could occur again.

The same problems involved in recording regional tsunamis of earthquakes origin are present in dealing with local waves generated by subaqueous slides and other means. Past records are incomplete, and some waves occur far from areas of habitation. Additionally, the mechanics of submarine failure are not always well understood or capable of ascertainment. Thus, uncertainties in degree of the effect and place of occurrence are great.

The Great Alaskan Earthquake of 1964 produced large scale subaqueous sliding in several of the key port cities in Alaska, causing extensive damage. The majority of the deaths are directly attributable to this cause. Numerous slides are known to have occurred in the area of Prince William Sound and the adjacent Kenai Peninsula.

Areas selected as being of particular concern and particularly susceptible to damage from local waves are those for which data are available and which have suffered from the effects of local waves in the past. As with the regional tsunamis, a cutoff point of 2-3 meters of runup has been selected for the reason previously discussed. Similarly, the runup heights are those from the level of the tide at the time of occurrence and the possibility of greater damage resulting from an occurrence at high tide level must be considered. The areas of particular concern identified in this report by this critieria are not exhaustive and are not intended to be predictive of areas which may suffer similar damages from more local waves.

Vulcanism

The southcentral region of Alaska is an integral part of the "Ring of Fire" which rims the entire Pacific basin. Including the volcanos which are strung out along the Aleutians, there are at least 60 volcanic centers in Alaska which have erupted in the past 10,000 years and which should be considered potentially eruptive. About 20 volcano ranging from Mt. Martin in the south to Mt. Torbert in the north, are of possible concern to communities on the coast (Table 3). There are three areas of particular concern where recent eruptions have caused significant damage, adversely affected human activities, or have the potential to do either in the immediate future. The areas all lie in the Cook Inlet region. They are Anchorage (fig. 10), the Drift River flood plain (fig. 12), and the eastern half of Lower Cook Inlet (fig. 9).

Table 3: Summary of recent and active volcanos, southcentral region.

Name	Approx. Summit Height feet (meters)	Date of Last Eruption
Martin	6,050 (1,844)	1960
Mageik	7,295 (2,210)	1953
Novarupta	3,200 (825)	1912
Knife Peak	7,600 (2,316)	
Trident	6,010 (1,832)	1968
Katmai	6,715 (2,047)	1931
Denison	7,400 (2,256)	
Steller	7,400 (2,256)	
Kukak	6,600 (2,012)	
Kaguyak	2,956 (855)	
Fourpeaked	6,903 (2,104)	
Douglas	7,000 (2,134)	
Augustine	4,304 (1,312)	1976
Iliamna	10,016 (3,052)	1953
Redoubt	10,197 (3,108)	1968
Double	7,192 (2,192)	
Black	6,509 (1,984)	
Spurr	11,070 (3,374)	1954
Torbert	10,000 (3,230)	1953 (?)

From: Alaska Regional Profiles, Southcentral Region; Univ. of Alaska, Arctic Environmental Information and Data Center, 1974.

Hazards associated with a violent volcanic eruption include severe blast effects, nuees ardentes, pyroclastic flows, lava flows, volcanic mudflows, turbulent clouds of ash and hot gases, lightning discharges, corrosive rains, flash and outburst floods, earthquakes and tsunamis. All of these primary and secondary phenomena have occurred in the southcentral region of Alaska in historic times. Of these effects, the most severe which could affect populated areas is the possibility of tsunamis, and secondarily, the possibility of ashfall or corrosive rains, and flash or outburst floods.

For the purposes of this report, volcanic areas of particular concern were defined on the basis of combined areas of historical eruptions and areas of population. The active volcanos are situated along the western side of Cook Inlet and Shelikof Strait and the areas of population are situated on eastern shores, (fig. D). Aside from the damage caused by a volcanic-generated tsunami, most effects of vulcanism on the populated areas would be short term. These effects include interference with air traffic, roof collapse, destruction of foliage or agricultural crops and corrosion of exposed metal. Though not necessarily damaging, the removal of ash could require considerable expenditure of labor and money. Areas on the west shore of Cook Inlet which lie near the flanks or within the drainage area of an active volcano, such as on the Drift River flood plain (fig. 12), should anticipate the possibility of destructive floods and mudflows.

Volcanos are by their nature unpredictable. Research is ongoing to enable scientists to predict with greater accuracy exactly when to expect a volcano to erupt. The effects of eruption are similarly difficult to predict, since each eruption may manifest different symptoms or effects. For example, ash fall and corrosive rains are dependent upon wind velocity, wind direction, particle size and density, and how high into the atmosphere the particles may ascend. Thus, areas affected once, such as Anchorage, may not have similar damage in a subsequent eruption.

Glacier Dammed Lakes and Outburst Floods

Glaciers cover an area of about 28,500 square miles in Alaska. They occur principally along the Pacific coast, in the southern central part of the state. Some of these glaciers flow across mouths of adjoining valleys and thereby cause lakes to form behind them. When these ice dams fail, catastrophic flooding may occur. A second kind of flooding may occur when a glacier clad volcano begins to heat up and become active. In that case, very rapid melting of the glacial ice can result in the discharge of large amounts of water. Both kinds of flooding have occurred in Alaska, and could potentially reoccur at any time. Flooding may occur in either case at any time of the year and is extremely difficult to predict.

Many of the coastal areas in which flooding occurs are either unpopulated or are identified as subject to flooding by other means. However, floods resulting from glacier dammed lakes present a serious potential hazard to population in several parts of the state and a very real limitation to development in areas of potential inundation. The areas identified in this report as being of particular concern are those where noteworthy outburst floods have occurred in the past and which are located in and near areas of development or potential development.

Distribution of Mineral and Energy Resources

Plate 2 is an attempt to delinenate those coastal areas of Alaska with the highest potential for nonrenewable resource deposits. The assumption in presenting Plate 2 is that such areas are also those most likely to have exploration and development activities in the foreseeable future.

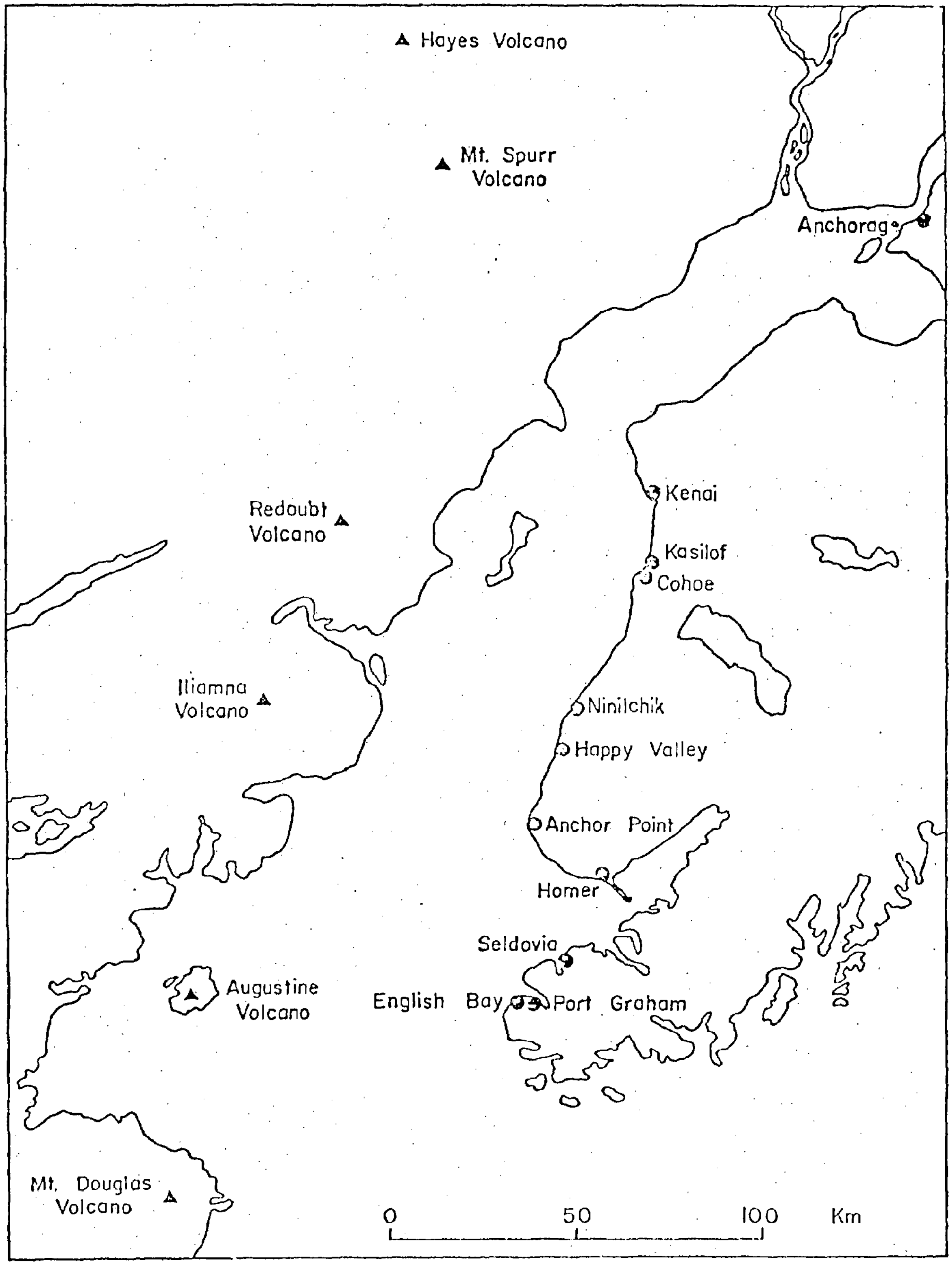


Figure D . Volcanoes of the Cook Inlet area, Alaska.

Specific areas have not been defined as APC's for reason of containing unusual deposits of nonrenewable resources. Instead, Plate 2 shows those coastal areas which are judged to have the highest potential relative to the entire remainder of the state for the occurrence of a variety of nonrenewable resources. Whether any particular one of these areas will ever be exploited depends not only on economic feasibility, but also on decisions of a political nature which go to issues of competing land uses, "highest use", and so forth. One of the purposes of identifying APC's is to aid in making wise coastal land management decisions. Consequently, it would be counterproductive (and technically impossible) to identify as APC's only those specific areas which are now supporting or will support in the very near future nonrenewable resource exploitation. Hence, areas of high potential for minerals and energy are shown at a relatively small scale.

Data on coal, oil and gas and minerals are shown on Plate 2. These data are subject to important constraints on interpretation. First, on-shore (3 - mile) areas with relatively high energy and minerals potential are based on priority rankings of 500,000 acre tracts for the entire state. The areas are defined in part by the boundaries of geologic (rock) provinces. Second, the minerals and coal rankings are relative to all land in the State; the oil-gas rankings are only for those land areas known to be underlain by potential reservoir rocks (mainly sedimentary rocks). Third, the rankings for each of the three classes of resources were made independantly of one another, and in general represent the relative likelihood of exploitable resources being found. "Exploitable" includes consideration of the unit value of the particular resources, potential size and concentration of the resource, and likely future demand (criticality) for the resource.

Fourth, and most important, the rankings are based on the total data available to Department of Natural Resources personnel at the time of compilation. Many areas of Alaska have been explored in detail but the data are proprietary and not available to the public; other areas have been explored only in reconnaissance fashion. In such cases of limited data the relative rankings represent the best professional judgment of the compilers, based in part on extrapolation of geologic conditions from adjacent areas.

In compiling Plate 2 from the original maps of individual resource classes, it was decided to show only the areas for each resource class which fell in about the upper one-third rank of all areas for that class. While such a decision is basically arbitrary, it seemed necessary in view of the requirement to define only areas of particular concern. On the other hand, to restrict the areas shown to only the upper 10% or so seemed to be potentially misleading; several of the highest rankings have been explored and announced only with the past few years and it is likely that future discoveries could be made in lower ranking tracts which are relatively unknown at present.

In view of the aforementioned limitations, the areas shown on Plate 2 should be considered only as a general guide to coastal areas most likely to contain exploitable nonrenewable resources. Available data on specific deposits (for example, U.S. Borax molybdenum deposit in southeastern) have been incorporated in ranking the broader areas shown. While such deposits are obviously areas of particular concern at present, future exploration and exploitation will occur in other areas as well.

Despite a growing public awareness that our nonrenewable resources are limited and that rational alternatives to exploitation must be developed, it is in the national interest that reasoned exploitation continue for the foreseeable future. Nonrenewable resources are an important part of Alaska's total resource base, and reasoned exploitation can be in the best interest of the State. An awareness of known resource deposits, and of the areas most likely to contain as yet undiscovered deposits, is necessary to complete a coastal management scheme. Areas can be tentatively identified for management purposes as possible areas of resource exploitation, and some areas of potential use conflict may be recognized early.

Plate 2 also includes the areas which might be capable of development as geothermal energy sites.

Candidate Sites for Tidewater Ports, Brooks Range Mineral Belt

The general area of the Brooks Range and Seward Peninsula has relatively high mineral potential. In the event that large-scale production is undertaken there, it is likely that overland shipment of ores would be to a tidewater port on the Seward Peninsula. Due to hazards posed by storm waves, shallow water, potentially unstable bottom, and annual ice, candidate sites for such a port or ports are probably limited to a few areas.

Several members of the mineral industry in Alaska have expressed their opinions on the most likely candidate sites. Because there is agreement among such members, we tentatively identify as APC's the following sites of potential tidewater ports (sites are shown on Plate 1). We have no detailed data on onshore and near offshore geologic conditions, nor do we know the precise likely locations of potential facilities within the general area of each site. Thus, the sites are identified only tentatively and are shown only at small scale on Plate 1.

(a) Cape Darby
(b) Point Jackson
(c) Cape Nome
(d) adjacent to the south end of the Mulgrave Hills, about two-thirds of the distance from Cape Krusenstern toward Kivalina.

(Sites are ranked in order of relative preference expressed.)

Lituya Bay

A. Geographical Location

1. Region: Southeastern Alaska, Eastern Gulf of Alaska
2. Latitude: 58° 36' 45" N
   Longitude: 137° 39' 30" W
3. Additional Information: U.S. Geol. Survey Quad. Mt. Fairweather (C-5, C-6), scale 1:63,360.

B. Area Description

1. General geologic setting: Lituya Bay is a long narrow inlet opening southwest onto the Gulf of Alaska. The deposits at the mouth of the bay consist of slightly modified glacial moraines and associated drift. These Quaternary deposits overlie late Tertiary siltstone, sandstone and sandy mudstone with locally abundant volcanic rocks, which are exposed on either side of the bay. The head of the bay is composed of Jurassic to Cretaceous graywacke, slate and minor conglomerate. The Fairweather fault, trending northwest, cuts across the head of Lituya Bay. It is probable that the bay is a valley which flooded after the retreat of Lituya Glacier, and/or North Crillion Glacier. The walls of the northeast end of the bay are remarkable for their steepness.

2. Criteria employed in identification as an APC: Lituya Bay is known for the giant waves produced by rock masses sliding from the steep walls at the head of the bay into the areas of the bay itself. In 1853 or 1854 a landslide produced waves with a runup in excess of 115 meters. Other landslide generated waves occurred in 1874 (6 m.), 1899 (60 m. -possibly triggered by earthquake near Yakutat), 1936 (140 m.-destroyed two cabins on Cenotaph Isand) and on July 9, 1958. The 1958 slide was triggered by a magnitude 7.9 earthquake and subsequent movement along the Fairweather fault system. The 1958 wave stripped off the forest on the opposite side of the fiord to over 500 meters, wrecked two boats, caused two deaths and produced a wave over 90 meters high at the mouth of the bay. About 35 million cubic meters of material from as high as 900 meters altitude slid from the northeast wall of Gilbert Inlet.

3. Reason for inclusion of this area as an APC: Although there are no permanent settlements in Lituya Bay, the event of July 9, 1958 indicates that the unique conditions which exist at Lituya Bay are a potential threat to life and property. Boats have been anchored in the bay when slides have occurred. Moreover, knowledge gained by study of the phenomenon which occurs with regularity in Lituya Bay may aid in preventing or anticipating similar occurrances in other areas near population centers.

4. Other: See figure 1.

Reference: Miller, D.J., 1960, Giant waves in Lituya Bay, Alaska, U.S. Geol. Survey Prof. Paper 354-C, p. 51-86.

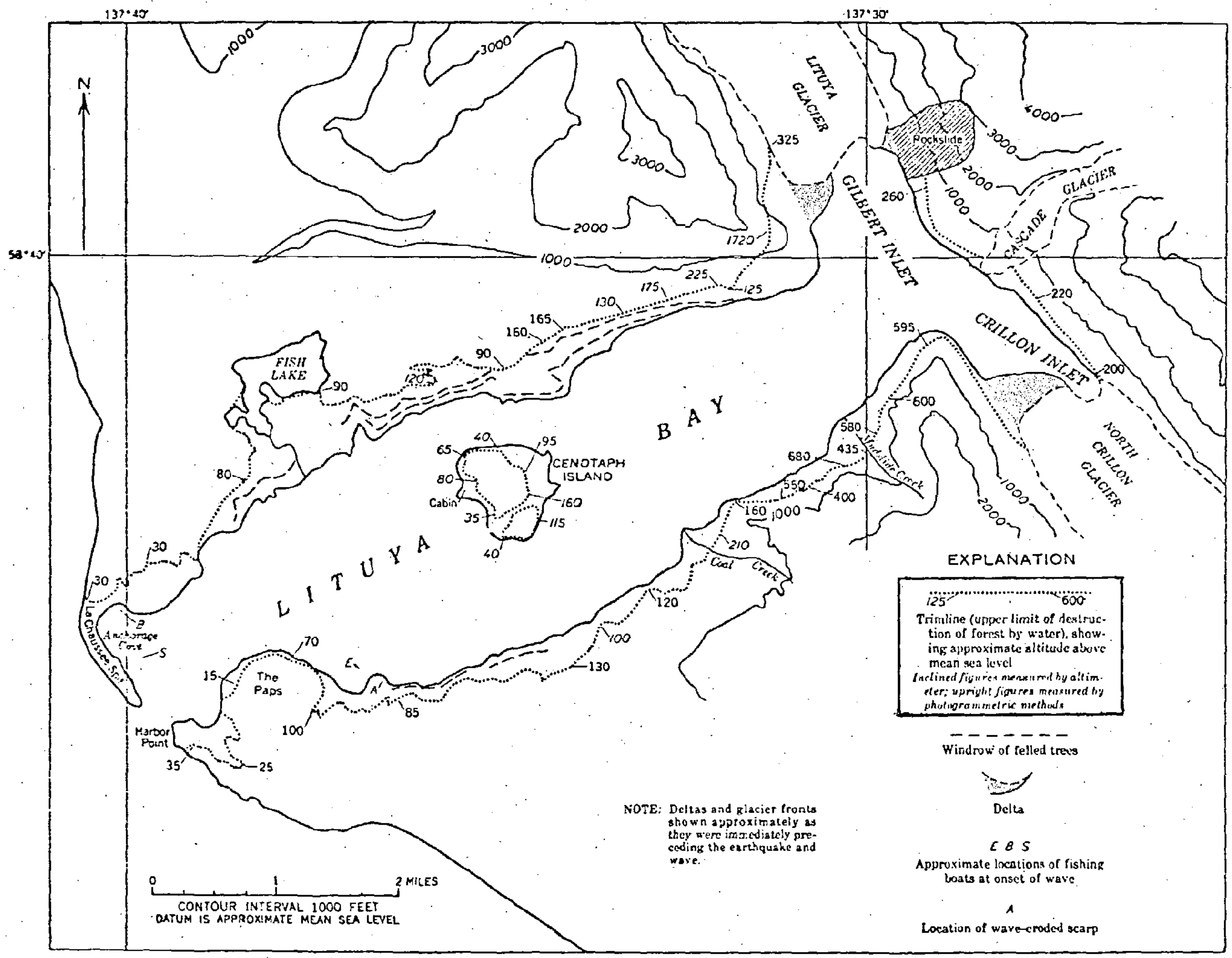


Figure 1: Map of Lituya Bay showing runup levels from giant wave of 1958. From Miller (1960).

Yakutat

A. Geographical Location

1. Region: Southcentral Alaska, Gulf of Alaska
2. Latitude: 59° 33' N
   Longitude: 139° 44' W
3. Additional Information: U.S. Geol. Survey Quad. Yakutat (B-4, B-5, C-4, C-5), scale 1:63,360.

B. Area Description

1. General geologic setting: Yakutat is situated on the southern shore of Yakutat Bay, which formed by marine inundation of a glacially scoured valley upon the retreat of Hubbard (?) Glacier in the past 500 years. The Malaspina Glacier is across Yakutat Bay directly to the north. Yakutat itself is situated upon prominent, slightly modified glacial moraines and associated drift left behind by the glaciers as they receded. Directly south of Yakutat are glaciofluvial deposits principally consisting of slightly to moderately modified outwash deposits. Coastal deposits found along the Gulf of Alaska coast include beaches, spits, and bars as well as older deposits of interlayered alluvial and marine sediments including local glacial drift. To the northeast, at the head of Yakutat Bay and on both sides of Russell Fiord, are graywacke, slate and minor conglomerate of Jurassic to Cretaceous age.

2. Criteria employed in identification as an APC: Yakutat has been hit at least once in historic times by earthquake generated tsunamis. On Sept. 10, 1899, an earthquake of magnitude 8.6 occurred approximately 55 km northeast at the head of Disenchantment Bay, generating a wave with over 9 m. of runup. There were no reported casualties or damage in 1899. However, waves generated in 1848 by a glacier icefall into Yakutat Bay killed 100 people. Similarly, an icefall into Disenchantment Bay caused waves with 35 m of runup in Yakutat Bay on July 4, 1905.

3. Reason for inclusion of this area as an APC: Although there are no reports of deaths or damage from tsunamis in recent years, Yakutat is situated on low lying unconsolidated sediments and would be susceptible to considerable damage from an earthquake or rock/icefall generated wave. Yakutat is the only development of size on the Gulf of Alaska coastline between Cordova and Sitka and with the possibility of offshore oil/gas development could increase in size and importance. It is the only sheltered port between Lituya Bay and Icy Bay.

4. Other: See figure 2.

Reference: Yehle, L.A., 1975, Preliminary report on the reconnaissance engineering geology of the Yakutat area, Alaska, with emphasis on evaluation of earthquake and other geologic hazards; U.S. Geol. Survey Open-File Report 75-529, 136 p.

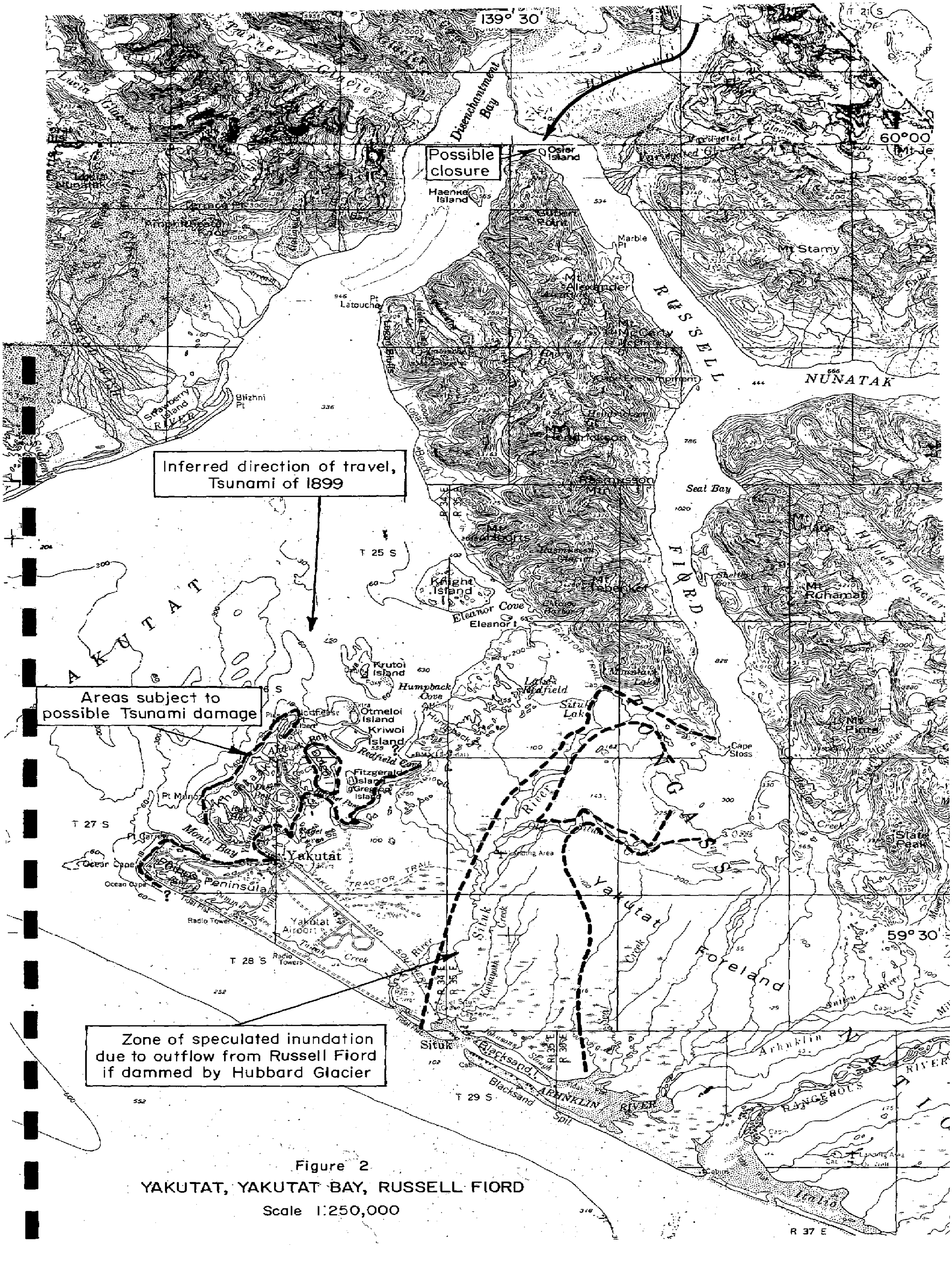


Figure 2
YAKUTAT, YAKUTAT BAY, RUSSELL FIORD
Scale 1:250,000

Yakutat Bay-Russell Fiord

A. Geographical Location

1. Region: Southcentral Alaska, Gulf of Alaska
2. Latitude: 60° 00' N
   Longitude: 139° 27' W
3. Additonal Information: U.S. Geol. Quad., Yakutat (D-4, D-5), scale 1:63,360 Mt. St. Elias, scale 1:250,000.

B. Area Description

1. General geologic setting: The Hubbard Glacier is 50 km long and covers an area of 3800 square km. It has advanced intermittently since first mapped in 1895 and was advancing as of 1977. If it continues to advance, the glacier will eventually close off the entrace to Russel Fiord, a 45 km long arm of the sea which will then become a fresh water lake. A glacier dammed lake was charted in this valley by Russian explorers in the early 1800's.

2. Criteria employed for identification as an APC: There is no present flood hazard but there is an extreme danger to boats near the glacier margin and in tidal currents at the mouth of Russell Fiord. When dammed, the lake could drain directly to Disenchantment Bay under or along the margin of Hubbard Glacier. Renewed increased overflow to the south as suggested by underfit streams in the vicinity of the present Situk River is highly probable, under such circumstances.

3. Reason for identification of this area as an APC: Although there is no present danger to any of the developments in Yakutat area, the possibility of the the lake developing behind Hubbard Glacier and spilling to the south should be considered if Yakutat expands to the southeast onto Yakutat foreland.

4. Other: See figure 2.

Reference: Post, A., and Mayo, L.R., 1971, Glacier dammed lakes and outburst floods in Alaska, U.S. Geol. Survey Map HA-455.

Yehle, L.A., 1975, Preliminary report on the reconnaissance engineering geology of the Yakutat area, Alaska, with emphasis on evaluation of earthquake and other geologic hazards; U.S. Geol. Survey Open-File Report 75-529, 136 p.

References: (continued)

Lahr, J.C., and Page, R.A., 1977, Earthquake activity and ground shaking in and along the eastern Gulf of Alaska, Alaskan OCS Principal Investigators Reports, Annual Report (1976-1977), BLM/NOAA, 31 p.

U.S. Department of the Interior News Release, May 4, 1977.

Icy Bay

A. Geographical Location

1. Region: Southcentral, Northern Gulf of Alaska
2. Latitude: 59° 55' N
3. Additional Information: U.S. Geol. Survey Quad., Icy Bay (D-2, D-3), Bering Glacier (A-2, A-3), scale 1:63,360.

B. Area Description

1. General geologic setting: Icy Bay is a north-trending fiord adjacent to the Gulf of Alaska. As recently as 1904 the entire area was overlain by glacial ice. The Guyot Glacier has been as much as 10 km seaward of the 1977 shoreline position. A terminal moraine located at the mouth of Icy Bay marks the limit of this advance. Ice retreat which began before 1910 has continued to the present with about 40 km of retreat through 1977. After the ice retreat, longshore sediment transport began building a spit complex on the east shore of Icy Bay where it meets the Gulf of Alaska. The spit has continued to develop and has hooked to the northeast. The Gulf of Alaska shoreline southeast of Riou Spit has steadily eroded northward by waves and longshore currents. The shore at Icy Cape is being similarly affected. Recent research indicates there is a zone of earthquake epicenters which extends northeast from the mouth of Icy Bay and implies that an active fault may run down the center of Icy Bay.

2. Criteria employed for identification as an APC: The Icy Bay area has many potentially hazardous or constraining geologic features, such as the shallow submarine moraine at the bay mouth and the icebergs which are constantly produced at the bay's head. The most significant hazard may be the high rates of shoreline erosion and sedimentation. An analysis of aerial photos indicates that the eastern shore has receded as much as 1.3 km in the past 35 years and over 8.2 km^2 of the western shoreline has disappeared, including all of Guyot Bay. In addition, Riou Spit may grow to eventually fill the bay just east of Moraine Island (Seal Camp Harbor). Guyot Glacier could readvance to its 1904 terminal position which could prevent use of the bay as well as any shoreline developments. However, the timing of such an advance is uncertain at present (L. Mayo, pers. comm. 1977).

3. Reason for inclusion of this area as an APC: Icy Bay is the sole shelter from storms between Yakutat and Kayak Island. It is the only sheltered bay near many of the offshore tracts that were leased for petroleum production in the April 1976 northern Gulf of Alaska lease sale, and has been considered as a primary onshore staging site for the support of offshore exploration and development. At least one private corporation has expressed interest in it as a development site. The continuing high level of seismicity and possibility that this activity represents an offshore continuation of an inferred thrust fault is an important constraint on development there.

4. Other: See figure 3.

Reference: Boothroyd, J., Cable, M.S., and Levey, R.A., 1976, Coastal morphology and sedimentation, Gulf of Alaska. Alaskan OCS Principal Investigators Reports, July-September 1976, BLM/NOAA, 84 p.

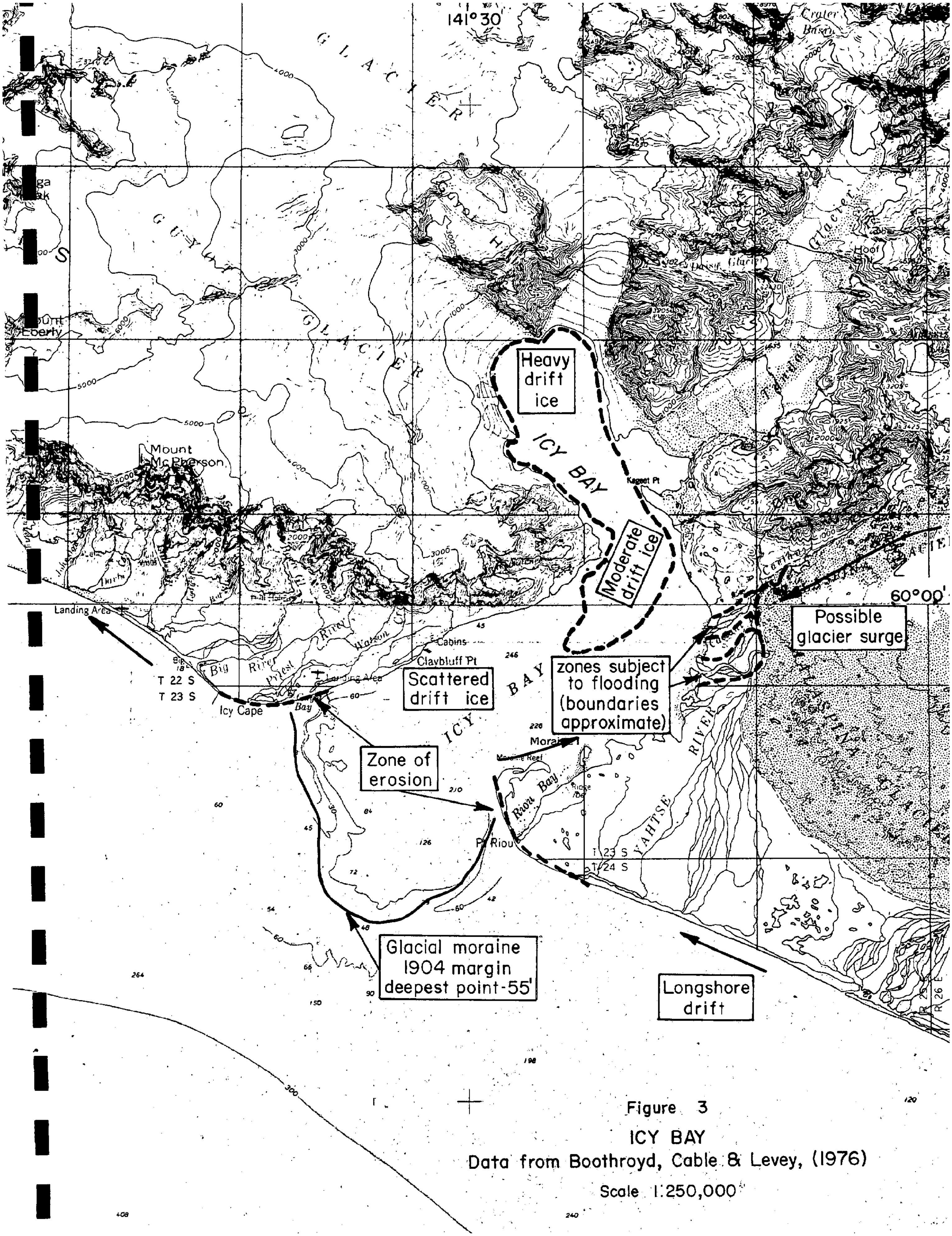


Figure 3

ICY BAY

Data from Boothroyd, Cable & Levey, (1976)

Scale 1:250,000

Copper River Delta

A. Geographical Location

1. Region: Southcentral Alaska, Gulf of Alaska
2. Latitude: 60° 33' N
   Longitude: 145° 45' W
3. Additional Information: U.S. Geol. Survey Quad., Cordova (C-2, C-3, B-3, B-4), Scale 1:63,360.

B. Description of Area

1. General geologic setting: Van Cleve Lake is formed behind part of Miles Glacier. The lake has a maximum area of 16 square km, and drains subglacially, probably every 1 to 3 years. An unnamed lake of approximately 2 square km is formed behind McPherson Glacier. It drains subglacially.

2. Criteria employed in identification as an APC: Van Cleve Lake drained catastrophically in 1909 and in 1912, destroying 500 m. of railroad trestle and drowning a man. This unnamed lake has drained twice within the last 15 years, washing out as much as a mile of the Copper River Highway.

3. Reason for inclusion of this area as an APC: With the construction of the Copper River Highway now in progress, future floods could present very serious hazards. All development within the delta area will have to take into account the possibility of such a flood occurring.

4. Other: See figure 4.

Reference: Post, A., and Mayo, L.R., 1971, Glacier dammed lakes and outburst floods in Alaska, U.S. Geol. Survey Map HA-455.

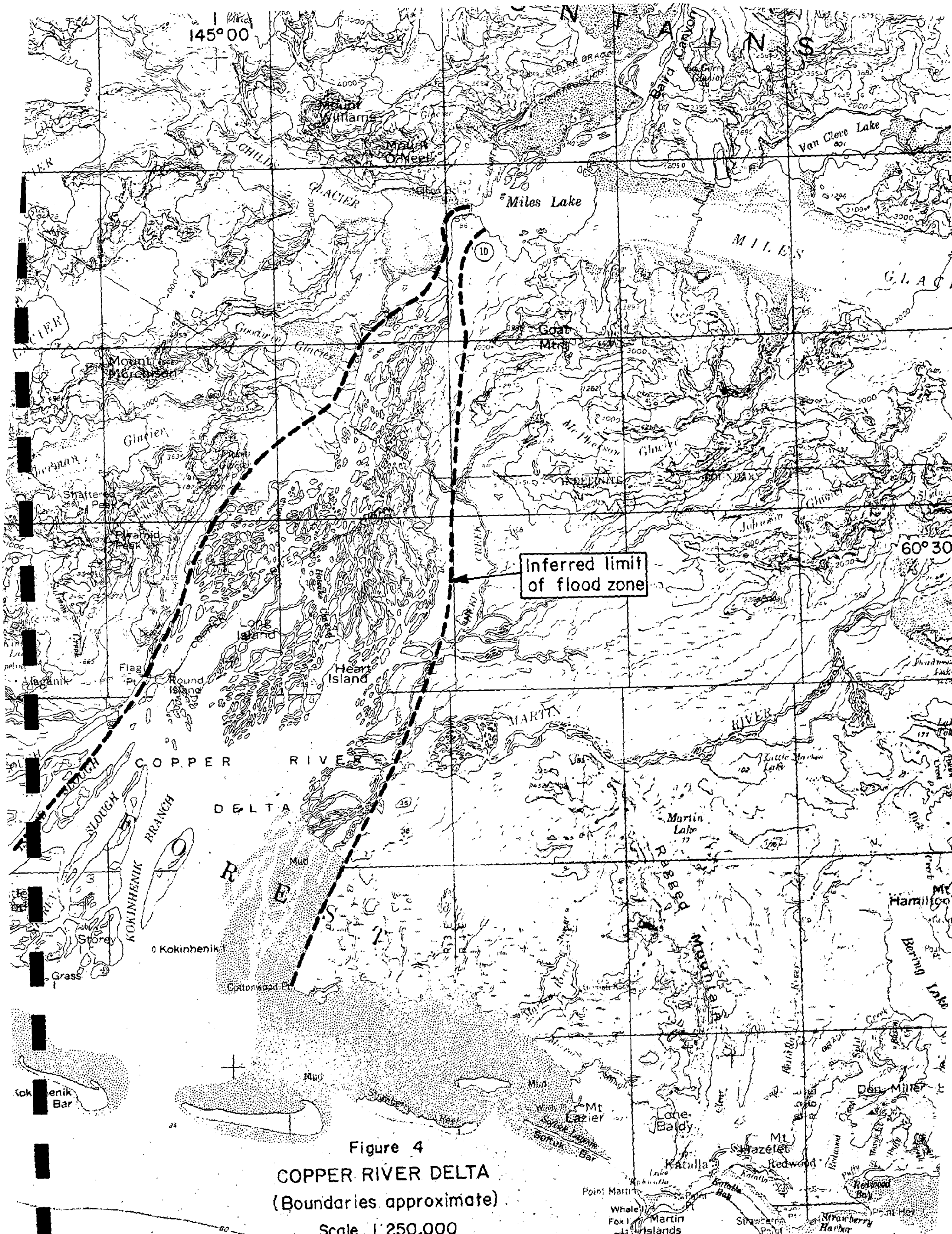


Figure 4
COPPER RIVER DELTA
(Boundaries approximate)
Scale 1:250,000

Valdez

A. Geographical Location

1. Region: Southcentral Alaska, Prince William Sound
2. Latitude: 61° 07' N
   Longitude: 146° 16' W
3. Additional Information: U.S. Geol. Survey Quad., Valdez (A-6, A-7), scale 1:63,360.

B. Area Description

1. General geologic setting: Valdez is located at the eastern end of Port Valdez, which comprises a narrow steep-walled glaciated fiord in the Chugach Mountains, and represents the northeasternmost extension of Prince William Sound. The engineering geology of the area has been extensively investigated because of the Trans-Alaska Pipeline Project. The bedrock consists of slate and graywacke mostly in thick beds with minor amounts of argillite, arkosic sandstone and conglomerate. At the eastern end of Port Valdez, outwash and alluvial plains from two rivers and from Valdez Glacier coalesce to form and broad delta. This delta is composed of a thick section of poorly consolidated silt, fine and sand and gravel and may be as much as 180 m. thick. Along the shoreline is a thin strip of tidal flats made up of silty sand and organic mud. The old town was located on these unconsolidated sediments. The new town sits on the Mineral Creek alluvial fan which is composed of medium dense to very dense cobble gravel in a matrix of medium to coarse sand. This fan is buttressed by an outlying bedrock ridge.

2. Criteria employed in identification as an APC: The earthquake of March 27, 1964, triggered a massive submarine slide along the entire face of the delta, involving approximately 98 million cubic yards of material. This slide destroyed the harbor ficilities and nearshore facilities. Waves generated by the slide and subsequent seiches did additional damage to the waterfront and the downtown area. These waves are estimated to have been 9 to 12 m. high. Fissures developed throughout the fine grained saturated deposits of the delta and caused structural damage in the downtown area. Some parts of the delta subsided below pre-earthquake high tide levels. Another massive submarine slide originating mainly at the site of Shoup Glacier end moraine in western Port Valdez produced waves with runups of over 35 meters in that area.

3. Reasons for inclusion of this area as an APC: The importance of Valdez to the economy of the State of Alaska is well known since it is the northernmost ice-free seaport in Alaska and the southern terminus of the Richardson Highway. It is the shortest and most direct route for tidewater to Fairbanks and interior Alaska. Furthermore, it is the southern end of the Trans-Alaska Pipeline and principal port for the export of oil. Even though the town was moved to the Mineral Creek fan after the destruction of a great part of the town in 1964, knowledge of the geologic conditions which exist in Valdez and caused the damage in 1964 may aid in planning in other areas of Alaska with similar circumstances.

4. Other: See figure 5.

References: Coulter, H.W., and Migliaccio, R.R., 1966, Effects of the earthquake of March 27, 1964 at Valdez, Alaska, Geol. Survey Prof. Paper p. C1-C36.

Plafker, G., Kachadoorian, R., Eckel, B., and Mayo, L.R., 1969, Effects of the earthquake of March 27, 1964 on various communities, U.S. Geol. Survey Prof. Paper 542-G, p. G1-G50.

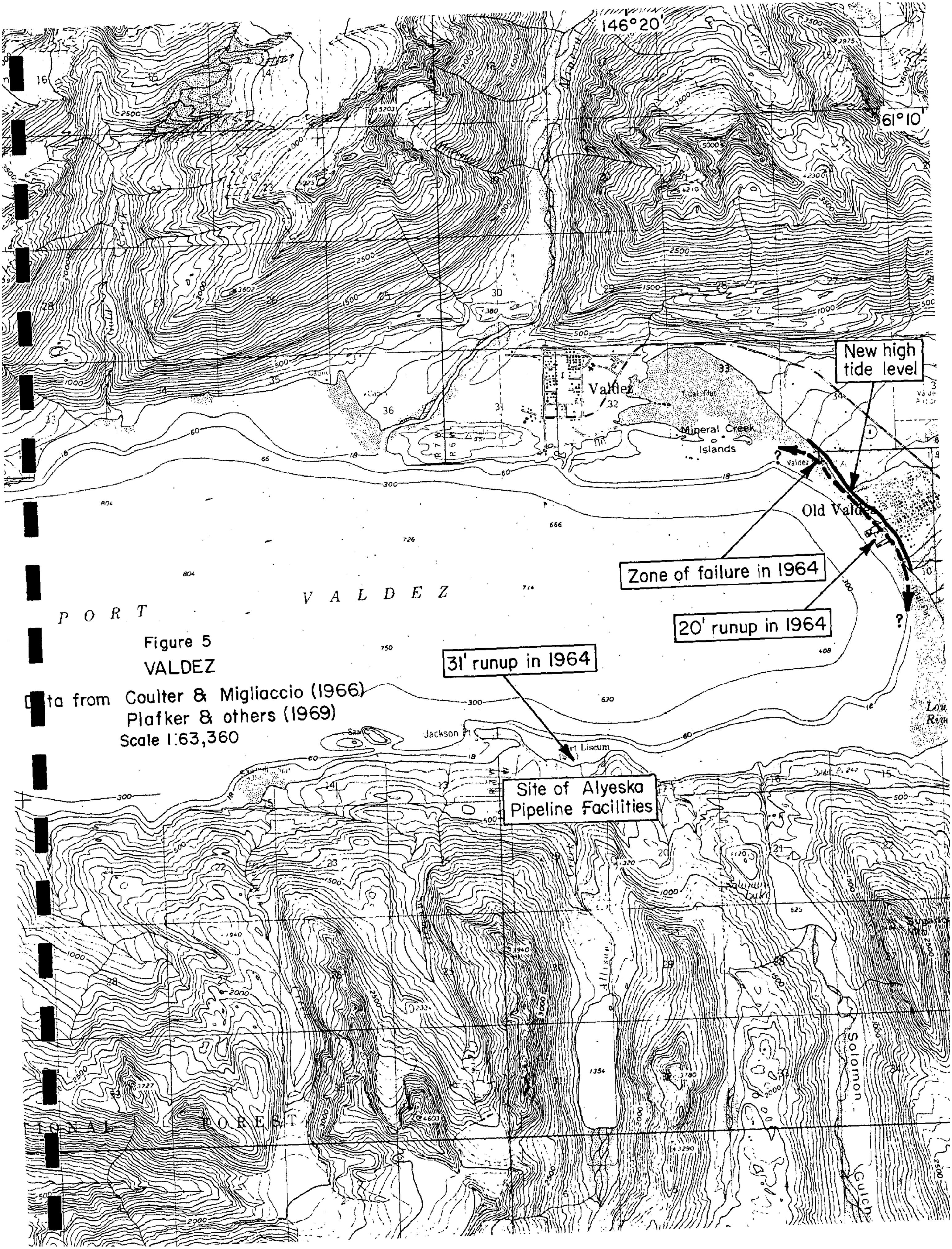


Figure 5
VALDEZ
Data from Coulter & Migliaccio (1966)
Plafker & others (1969)
Scale 1:63,360

Columbia Glacier

A. Geographical Location

1. Region: Southcentral Alaska
2. Latitude: 60° 59' 30" N
   Longitude: 147° 02' 30" W
3. Additional Information: U.S. Geol. Survey Quad., Seward (D-1), Cordova (D-8), Anchorage (A-1), Valdez (A-8), scale 1:63,360.

B. Description of Area

1. General geologic setting: Columbia Glacier is the largest glacier in Prince William Sound at 1,100 km^2. While most Alaskan tidal glaciers have made large-scale drastic retreats, Columbia Glacier has been in a state of near equilibrium for over 175 years, and is the only tidal glacier remaining on the North American continent which is still in an extended position. Current Columbia Glacier ends on a shoal interpreted to be a terminal moraine, which extends across Columbia Bay. Radar soundings of ice thickness indicate that the shoals at the terminus do not continue under the ice for any great distance, and for at least 30 km up the glacier much of the bottom is far below sea level.

2. Criteria for identification as an APC: Although the terminus of Columbia Glacier has been virtually stable, icebergs drift into shipping lanes in northern Prince William Sound and the approaches to Port Valdez. The stability of this glacier is anomalous with that of other Alaskan tidal glaciers, which have previously undergone large scale retreats. Large embayments which form at the terminus may present a serious hazard to the glacier's continued stability. A drastic retreat would be associated with increased iceberg discharge, and such could occur within a few years should the glacier retreat from the shoals.

3. Reason for inclusion of this area as an APC: The approaches to Port Valdez are the only shipping lanes to the southern terminal of the Trans-Alaska Pipeline. The large number of icebergs floating into shipping lanes produces a significant hazard to vessels such as large oil tankers.

4. Other: See figure 6.

Reference: Post, A., 1975, Preliminary hydrography and historic terminal changes of Columbia Glacier, Alaska; U.S. Geol. Survey Map HA-559.

Post, A., 1977, Reported observations of icebergs from Columbia Glacier in Valdez Arm and Columbia Bay, Alaska, during the summer, 1976, U.S. Geol. Survey Open-File Report No. 77-235, 7 p.

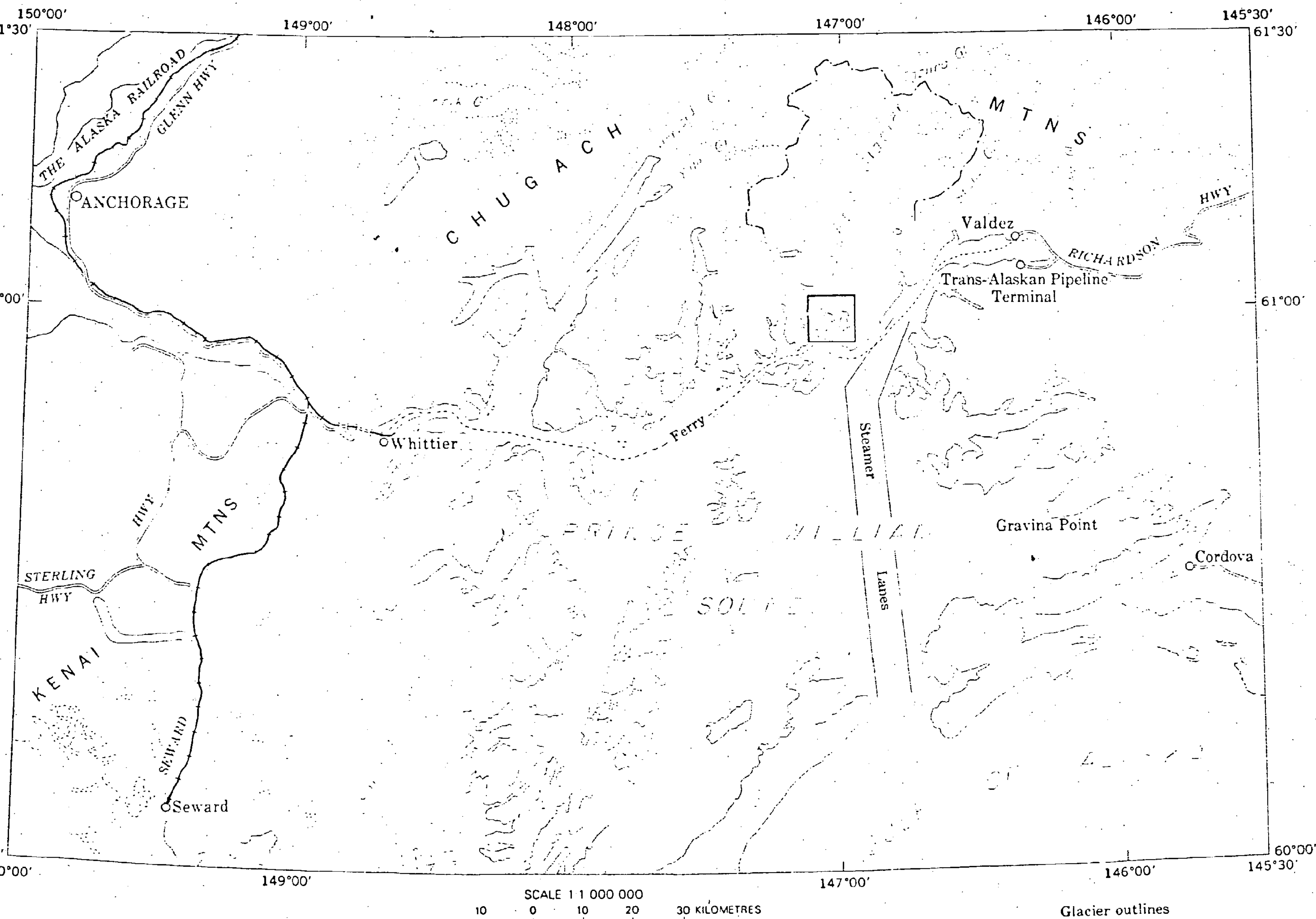


Figure 6: Regional setting of Columbia Glacier. From Post (1976).

Whittier

A. Geographical Location

1. Region: Southcentral Alaska, Prince William Sound
2. Latitude: 60° 46' 30" N
   Longitude: 148° 41' 00" W
3. Additional Information: U.S. Geol. Survey Quad., Seward (D-5), scale 1:63,360.

B. Area Description

1. General geologic setting: The bedrock in the Whittier area consists of Cretaceous (?) rocks, predominately slate but containing minor amounts of graywacke. Along the shores the bedrock has been intruded by four quartz diorite or diorite dikes or sills. Unconsolidated deposits consisting of outwash and stream gravels form the delta upon which Whittier rests and the southern part of the delta at the head of Passage Canal. The deposits at the northern part of the delta are overlain by a glacial moraine.

2. Criteria used as identification as an APC: On March 27, 1964, an earthquake of magnitude 8.5 struck southcentral Alaska. Submarine landslides triggered by this earthquake produced at least two, and probably three waves, which severely damaged the waterfront in Whittier and killed 13 people. In Whittier itself, maximum runup was 13 m. but other parts of the Passage Canal showed evidence of a maximum runup of as much as 32 m.

3. Reason for inclusion of this area as an APC: Whittier was built during World Was II to provide an all weather terminal for the Alaska Railroad. Its importance to the State can be appreciated when it is noted that due to the destruction of the ports at Seward and Valdez during the 1964 earthquake, the loss of Whittier port facilities left Alaska without any all-weather port for unloading supplies for movement inland either by rail or highway. Because the submarine slopes in Passage Canal were not significantly decreased by the landsliding during the earthquake, more slides and corresponding destructive waves may be expected in the wake of another earthquake of comparable magnitude.

4. Other: The town of Whittier is owned and operated by the U.S. Government, though some of the land has been leased to private enterprise. See figure 7.

Reference: Kachadoorian R., 1965, Effects of the earthquake of March 27, 1964, at Whittier, Alaska, Geol. Survey Prof. Paper 542-B, p. B1-B21.

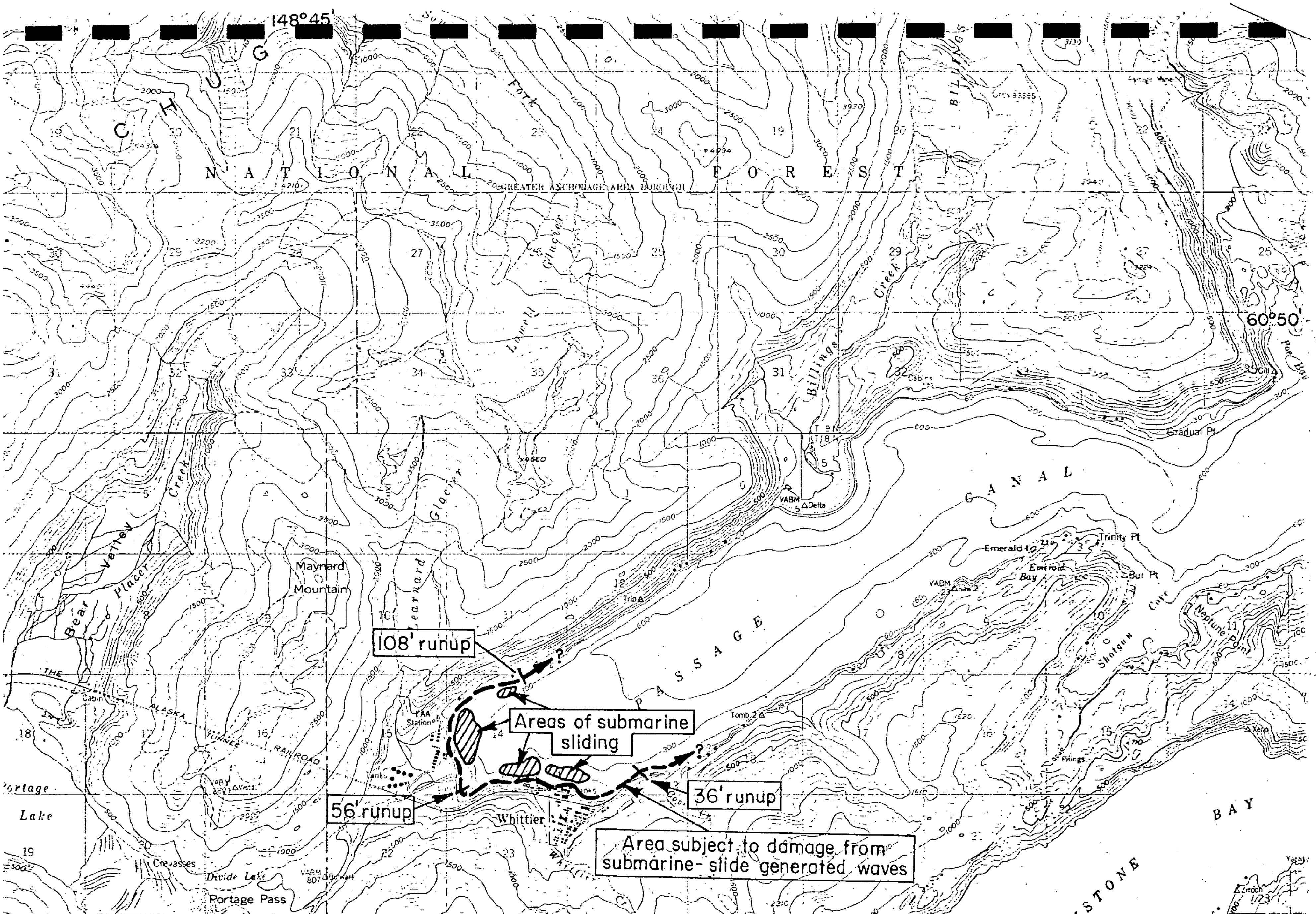


Figure 7
WHITTIER
Data from Kachadoorian (1965)
Scale 1:63,360

Seward and Resurrection Bay

A. Geographical Location

1. Region: Southcentral Alaska
2. Latitude: 60° 06' 30" N
   Longitude: 149° 26' 30" W
3. Additional Information: U.S. Geol. Survey Quad., Seward (A-7), scale 1:63,360.

B. Area Description

1. General geologic setting: The town of Seward sits at the northern end of Resurrection Bay. The main part of the residential and commercial area hugs the western side of the bay and is located on alluvial fan and fan-delta deposits which consist chiefly of loose sand, gravel and silt which have been deposited at the mouth of Lowell Creek. The town is expanding northwards onto the alluvial plain of the Resurrection River which feeds into the northern end of Resurrection Bay. Deposits there consist of sand and fine to medium gravel with minor amounts of silt and cobbles. These unconsolidated fluvial and other glacial deposits overlie bedrock which crops out mostly on the steep slopes along the walls of the bay. The bedrock consists of slightly metamorphosed graywacke and phyllite with a few conglomerate beds and is upper Cretaceous in age. There are some beach, deltaic and estuarine sediments deposited on intertidal flats at the head of the bay and along margins of some of the fans. The surrounding area is very rugged and is characterized by numerous glaciers.

2. Criteria employed in identification as an APC: As a result of the earthquake of March 27, 1964, slide-generated waves, seismic sea waves and possibly seiche waves overran the shores in the Seward area. Along the waterfront a strip of land about 1200 m. long and 15 to 150 m. wide slid into the bay concomitantly with offshore submarine sliding. Large scale sliding also occurred in the delta deposits at the mouth of the Resurrection River. The sea waves were generated by uplift in the seafloor in the Gulf of Alaska and arrived about 25 minutes after shaking stopped. These waves did considerably more damage to the already devastated waterfront. They had a runup as high as 12 m., and went as much as 1.5 km inland at the north end of Resurrection Bay.

3. Reason for inclusion of this area as an APC: Seward was one of the most heavily damaged towns in Alaska as a result of the earthquake of 1964. Much information gained by study of the conditions which led to the damage has been used in reconstructing the town. However, if a major earthquake strikes in the vicinity in the future, similar landsliding and wave damage can be expected. Since Seward is one of the few icefree ports in Alaska, its presence is criticial to the economy of Alaska. However, it must be recognized that the risk of damage to harbor and dockside facilities exists since it is not feasible to relocate them in sheltered areas or to provide breakwaters to minimize the risks.

4. Other: See figure 8.

Reference: Lemke, R.W., 1967, Effects of the earthquake of March 27, 1964 at Seward, Alaska, U.S. Geol. Survey Prof. Paper 542-E, p. E1-E43.

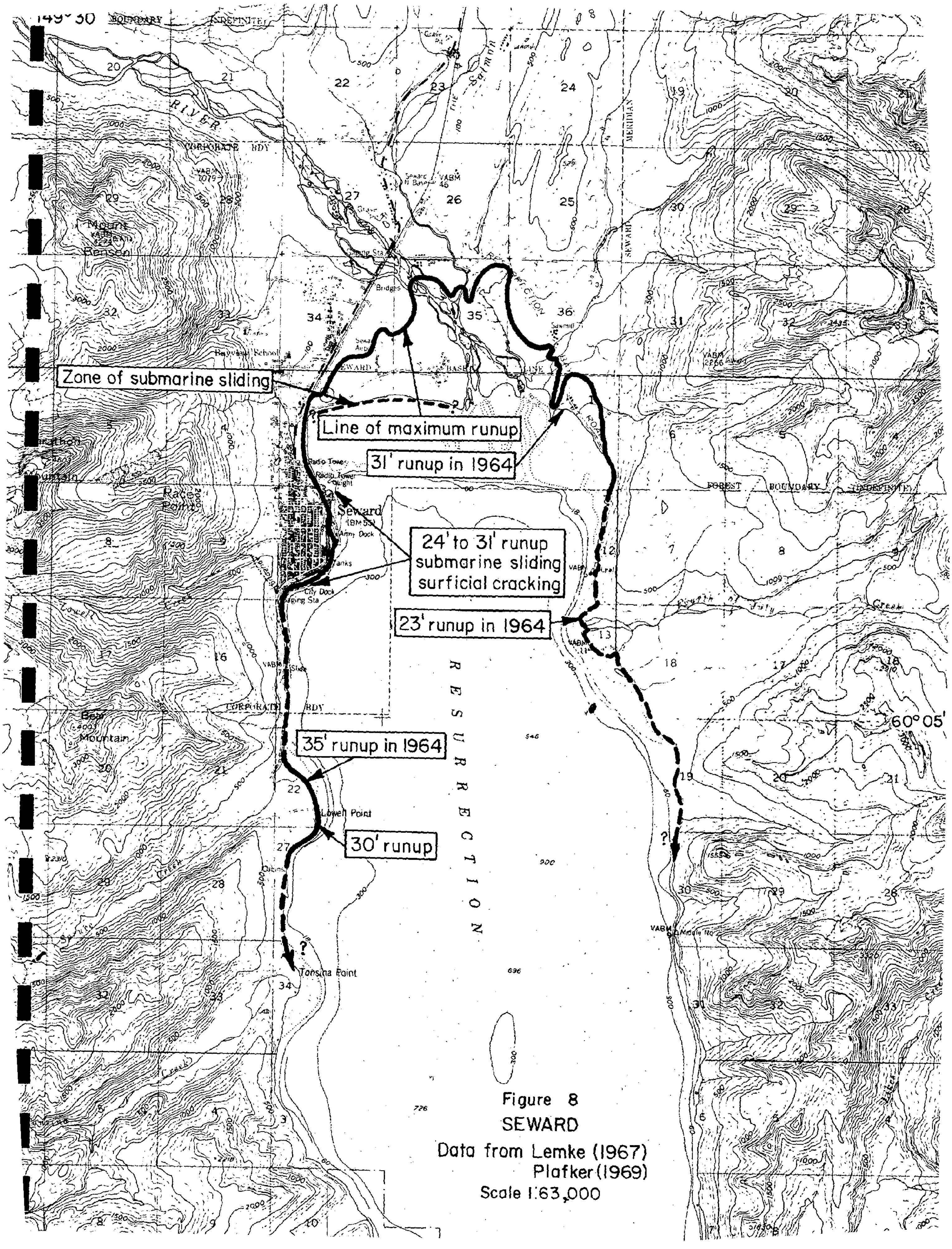


Figure 8
SEWARD
Data from Lemke (1967)
Plafker (1969)
Scale 1:63,000

Lower Cook Inlet

A. Geographical Location

1. Region: Southcentral Alaska, Lower Cook Inlet Area
2. Latitude: 59° 15' N to 60° N
   Longitude: 151° W to 154° W
3. Additional Information: U.S. Geol. Survey Quad., Iliamna, Seldovia, Kenai, Tyonek, Anchorage, scale 1:250,000.

B. Area Description

1. Geographical boundaries: Tsunamis generated by volcanic activity on Mt. Augustine have the potential to strike the Lower Cook Inlet shoreline, either on the east or the west shores. However, aside from a few scattered cabins, the west shore is unpopulated whereas the east shore supports several small fishing villages and the towns of Seldovia and Homer. Data are somewhat incomplete for the east shore since the major tsunami occurred before monitoring devices were available. Accounts which are confused in the literature are based mainly upon eyewitness reports. Thus, only the areas around centers of population have been considered as APC's. Generally, this defines the area of concern as the low-lying coastal areas on either side of Kachemak Bay and the western tip of the part of the Kenai Peninsula which contains the Kenai Mountain Range. Towns falling within this area of particualr concern include Homer, Anchor Point, Seldovia and Port Graham.

2. General geologic setting: The area of concern is best divided into two units for the purposes of describing the geology. The area bordering the northern half of Kachemak Bay is an area of low relief. The subsurface bedrock of mid-Jurassic to Late Cretaceous age is composed of continental shelf deposits of sandstone, siltstone, shale, limestone and claystone with some conglomerates and mudstone. This bedrock is overlain everywhere by Tertiary sandstones, shales and conglomerates which are overlain by Quaternary glacial moraine and drift deposits. Along some river valleys are found generally well sorted floodplain, terrace and fan deposits. The Homer area is slightly west of the Border Range fault system which trends northeast at the base of the Kenai Mountains and which is covered by recent glacial deposits.

   The area on the south side of Kachemak Bay is characterized by an irregular coastline. Bedrock consists of minor amounts of Tertiary siltstones, sandstone and conglomerates, which overly mildly to strongly metamorphosed Triassic (?) to Cretaceous rocks. These latter rocks include a deepwater sedimentary sequence of graywacke, siltstone, slate, sandstone and conglomerate interbedded with volcanic basalts and detritus. The Border Range fault system continues near the coast in this area.

3. Criteria employed for identification as an APC: Mt. Augustine is an island volcano at the mouth of Cook Inlet about 65 miles west of Seldovia across Lower Cook Inlet. It is primarily andesite, a composition that characteristically produces relatively violent eruptions. It has erupted several times in the past 100 years. On October 6, 1883, a particularly violent eruption produced mudflows and nuees ardentes which descended the sides of the volcano and entered the shoal waters of the north shore of the island, generating sea waves which traversed lower Cook Inlet. At least three waves reported to be 7-9 meters high hit Port Graham across the inlet. It is possible that the wave struck considerately more coastline but

the area was sparcely settled at the time and records do not accurately reflect the extent of the destruction.

4. Reason for inclusion of this area as an APC: Mt. Augustine is particularly dangerous because of its marine location and proximity to areas of population. The tsunami produced in 1883 struck settlements while the tide was at low ebb, but if one struck at high tide considerable damage or loss of life could result. The shores and flats of Cook Inlet (e.g., Homer Spit) are at present potentially exposed to similar inundations produced during explosive eruptions. Mt. Augustine is active and has shown considerable activity recently in 1963 and 1976, and although it is not possible to predict at this time when another explosion will occur, such an event is not an unlikely possibility. The volcano is being monitored presently by geophysicists from the University of Alaska.

5. Other: It must be kept in mind that designation of areas in Kachemak Bay as APC's is neither predictive or inclusive. There are factors associated with an eruption of Mt. Augustine that might have a controlling influence on the effects of such an eruption and which are impossible to predict. Moreover, the amount of data available is insufficient to allow an accurate determination of exactly where a wave generated by volcanic activity would strike. For example, the western shore of Cook Inlet could be struck by tsunamis generated by a westward flow of material from the crater of Mt. Augustine. Such an occurrence would be of minor significance compared to a wave generated eastwards since the west shores are sparcely populated. The eastern side of Lower Cook Inlet, in particular the areas of Kachemak Bay, have more people and property, and have the greatest risk of damage from a tsunami. Correspondingly, those parts of the populated areas within 6 to 9 meters of mean higher high water are the areas of particular concern. Included are Port Graham, English Bay, Seldovia, Homer (particularly the Homer Spit), and other areas of development or potential development. Research is currently underway to determine whether an eruptive phase at Mt. Augustine can be predicted through an analysis of seismic activity and tidal triggering.

6. Other: See figure 9. See figure D for the proximity of Mt. Augustine and other active volcanos to the communities of Cook Inlet.

Reference: Kienle, J., and Forbes, R.B., 1977, Augustine -- Evolution of a volcano: Annual Report (1975-1976) Geophysical Institute, University of Alaska, (Fairbanks), p. 26-48.

Pulpan, H., and Kienle, J., 1977, Seismic and Volcanic risk studies-western Gulf of Alaska, Alaskan OCS Principal Investigators Annual Reports, 1976-1977, BLM/NOAA, p. 107.

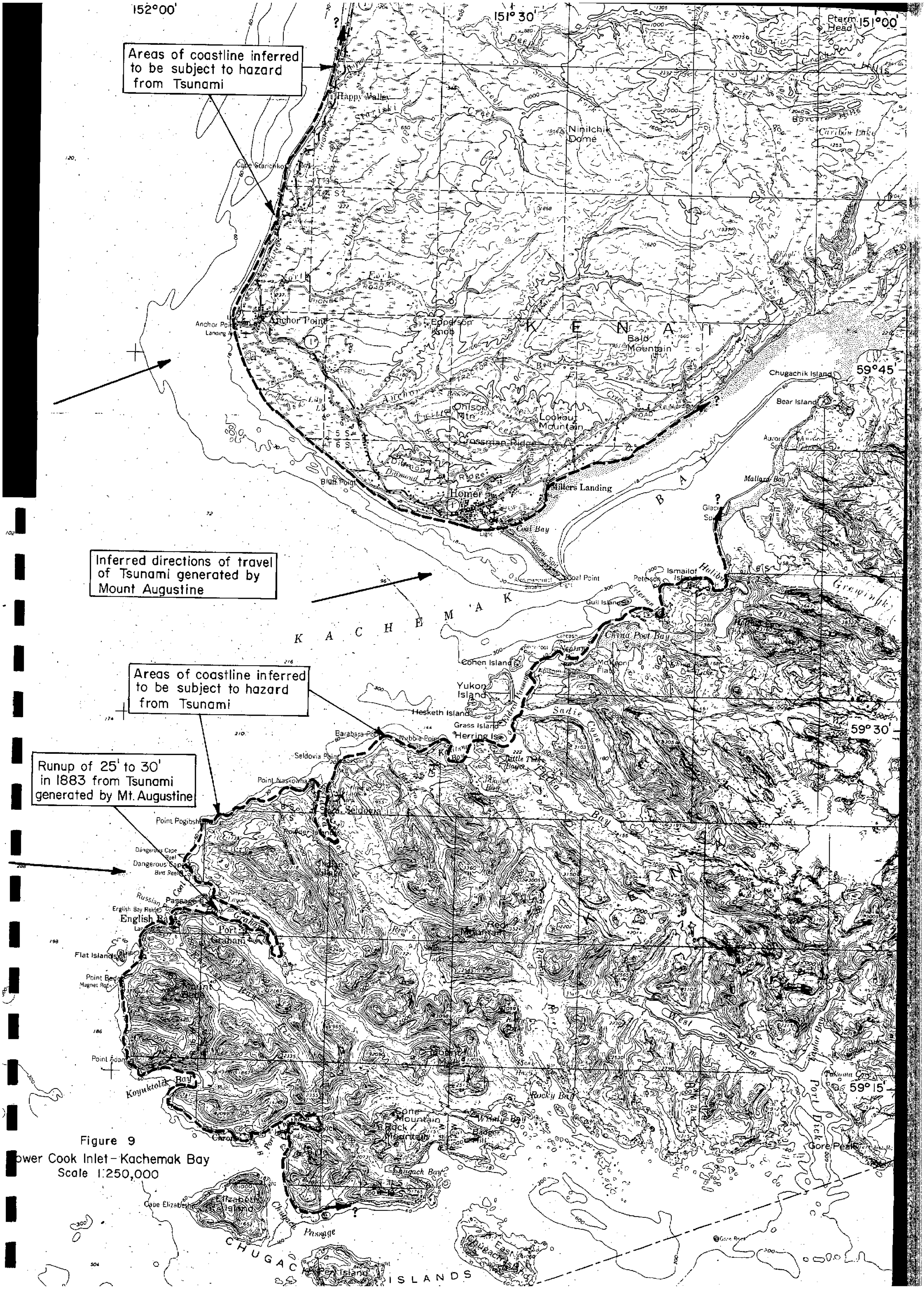


Figure 9
ower Cook Inlet – Kachemak Bay
Scale 1:250,000

Anchorage

A. Geographical Location

1. Region: Southcentral Alaska, Cook Inlet
2. Latitude: 61° 13' N
   Longitude: 149° 53' W
3. Additional Information: U.S. Geol. Survey Quad., Anchorage (A-8), Tyonek (A-1), scale 1:63,360.

B. Area Description

1. General geologic setting: The City of Anchorage is located on a broad plain at the foot of the Chugach Mountains. Bedrock beneath the plain comprises siltstones, sandstones, conglomerate, and coal of Tertiary age. Bedrock is overlain by as much as 450 meters of unconsolidated deposits, largely of glacial origin. Of particular interest here is the Bootlegger Cove Clay, an estuarine (marine) deposit of interbedded clays, silts, and sands. Marine shells from the Bootlegger Cove Clay have recently been radiometrically dated and they indicate a time of deposition of about 14,000 years ago. The deposit is now thought to have formed soon after maximum glacial advances, when world-wide sea level had begun to rise; subsequently, isostatic rebound (uplift) began after deglaciation of Upper Cook Inlet and eventually the Bootlegger Cove Clay attained its present position. The top of the deposit is 60 to 80 feet above mean sea level.

2. Criteria employed in identification as an APC: Failures of the Bootlegger Cove Clay during the 1964 Prince William Sound earthquake were responsible for several destructive landslides in Anchorage. Major landslide areas are the Fourth Avenue slide, the L Street slide, the First Avenue slide, the Government Hill slide, and the Turnagain Heights slide (see Plate 3 for the locations of these slides).

   The aforementioned areas are all adjacent to moderate to steep slopes. Evidence of older slides (now locally vegetated) along these slopes indicates that sliding occurred there before the catastrophic failures in 1964. Among the factors which probably contributed to the 1964 failures are the following:
   a. relatively long duration of seismic shaking;
   b. presence of marine clays with potentially high sensitivity;
   c. potential liquefaction of saturated sand horizons within the Bootlegger Cove Clay;
   d. presence of steep free faces.

   Geotechnical tests carried out after the 1964 failures indicate that parts of the Turnagain slide have very low shear strengths at several depths between 28 feet and 45 feet. The surface of sliding may coincide with such low strength zones.

   The specific areas of particular concern identified herein are those areas where landslides have occurred in the past, and where conditions are thought to be conducive to potential major failures in the future. (See Plate 3, "Areas of Potential Large Landslides".)

3. Reason for inclusion of this area as an APC: Anchorage is a coastal community and is Alaska's largest city. The city has grown remarkably since the 1950's, and some growth is likely to continue for the forseeable future. Land near the city center is at a premium.

Development on and immediately adjacent to the APC's identified herein should be permitted only with a clear understanding of the potential hazard involved. In particular, site-specific evaluations of proposed development sites should be carried out by qualified engineers, and the potential for catastrophic ground failure at the site addressed.

4. Other: Mt. Spurr erupted in 1953. Despite being located 140 km. west of Anchorage, up to .6 cm of volcanic ash was deposited in the city in 6 hours. The effects were only short term, but considerable effort and money were expended in cleaning up and attempting to stop corrosion. Health and property damage in the event of a recurrence could be minimized by advance planning of public warnings and instructions. See figure 10.

References: Hansen, W.E., 1967, Effects of the earthquake of March 27, 1964, on Anchorage, Alaska; U.S. Geol. Survey Prof. Paper 542-A.

Dobrovolney, E., and Schmoll, H.R., 1974, Slope stability map of Anchorage and vicinity, Alaska; U.S. Geol. Survey Map I-787-E. (Plate 3 of this report).

Wilcox, R.E., 1959, Some effects of recent volcanic ash falls, with special reference to Alaska; U.S. Geol. Survey Bull. 1028-N, p. 409-476.

Schmoll, H.R., Szabo, B.J., Rubin, M., and Dobrovolney, E., 1972, Radiometric dating of marine shells from the Bootlegger Cove Clay, Anchorage area, Alaska; Geol. Soc. America Bull., v. 83, p. 1107-1114.

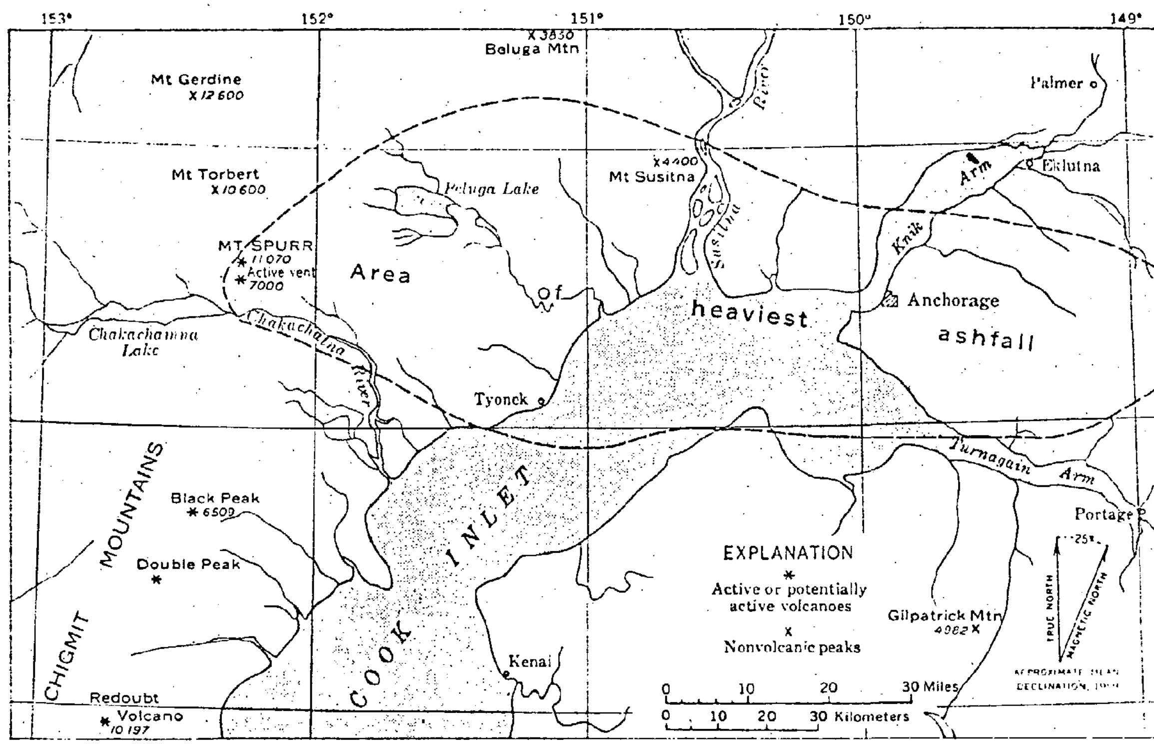


Figure 10: Map of area of ashfall from eruption of Mt. Spurr, 1953. From Wilcox, (1959).

Knik River Outwash Plain

A. Geographical Location

1. Region: Southcentral Alaska, Upper Cook Inlet
2. Latitude: 61° 29' N
   Longitude: 149° 16' W
3. Additional Information: U.S. Geol. Survey Quad. Anchorage, scale 1:250,000.

B. Area Description

1. General geologic setting: Lake George has been in recent years the largest glacier dammed lake in Alaska, attaining a maximum area of 70 sq. km. The lake forms by glacier advance, and closing of the outlet channel by the ice, and fails by erosion and/or hydrostatic uplift of the ice. It drains into the Knik River through a gorge along the margin of Knik Glacier. From 1918 through 1966, except for 1963, it flooded Knik River annually. From 1949 through 1961 there was a significant increase in the peak discharges. Due to a thinning of the ice at the glacier terminus, the peak discharges from 1962-1966 were lower. The failure usually occurred in July or August. Since 1966, Knik Glacier has failed to form an ice dam and the lake has not filled. At peak times of flood, the discharge in the Knik River has been in excess of 12,000 cubic meters per second, and has risen as much as 7 meters.

2. Criteria used in identification as an APC: Although Lake George last emptied in 1966, a series of positive ice balances may stimulate Knik Glacier to advance and dam the lake again. If so, then outburst discharge in the Knik River would cause an extreme flood hazard along the Knik River flood plain.

3. Reasons for identification of this area as an APC: The Knik River vicinity is among one of the fastest growing areas in Alaska, and contains the major arteries of trade from Anchorage to the Interior. This area will continue to grow in the future, and such expansion should take into account the possible dangers of a flood of the magnitude that the Knik Glacier is capable of producing. It should be emphasized that the potential for renewed advance of the Knik Glacier is presently uncertain.

4. Other: Because of the spectacle of the breakout, the area has been proposed as a natural landmark by the National Park Service several times. U.S. Army Corps of Engineers may begin detailed study in 1978 to precisely define the floodplain limits along lower Knik River.
   See figure 11.

Reference: Post, A., and Mayo, L.R., 1971, Glacier dammed lakes and outburst floods in Alaska, U.S. Geol. Survey Map HA-455.

Figure 11
KNIK RIVER FLOOD PLAIN
(Boundaries approximate)
Scale 1:250,000

Drift River Delta

A. Geographical Location

1. Region: Southcentral Alaska, Cook Inlet
2. Latitude: 60° 35' N
   Longitude: 152° 28' W
3. Additional Information: U.S. Geol. Survey Quad., Kenai (B-7, C-6, C-7), scale 1:63,360.

B. Area Description

1. General geologic setting: Redoubt Volcano is an active volcano in the chain of volcanos along the mountains bordering the west shore of Cook Inlet. It is over 3,000 meters high and is covered in glaciers and snow. During an eruption beginning on January 24, 1966, a large amount of water from snow and ice melt and mud was released and descended from the summit crater. These waters then proceeded down the nearby Drift River.

2. Criteria employed for identification as an APC: Recurrent explosions and turbulent clouds have triggered flash floods in Drift River from the sudden melting of the glaciers on the mountain. Redoubt Volcano is considered active and is capable of renewed activity at any time, producing more flooding.

3. Reason for inclusion of this area as an APC: A major petroleum pipeline terminal and tank storage farm which serves several of the oil fields in Cook Inlet, is located at the mouth of the Drift River. It was built after the floods in 1966, and was engineered for such a contingency. However, Redoubt Volcano could heat up and produce flood waters of equal or greater magnitude than those produced in 1966.

4. Other: See figure 12.

Reference: Post, A., and Mayo, L.R., 1971, Glacier dammed lakes and outburst floods in Alaska, U.S. Geol. Survey Map HA-455.

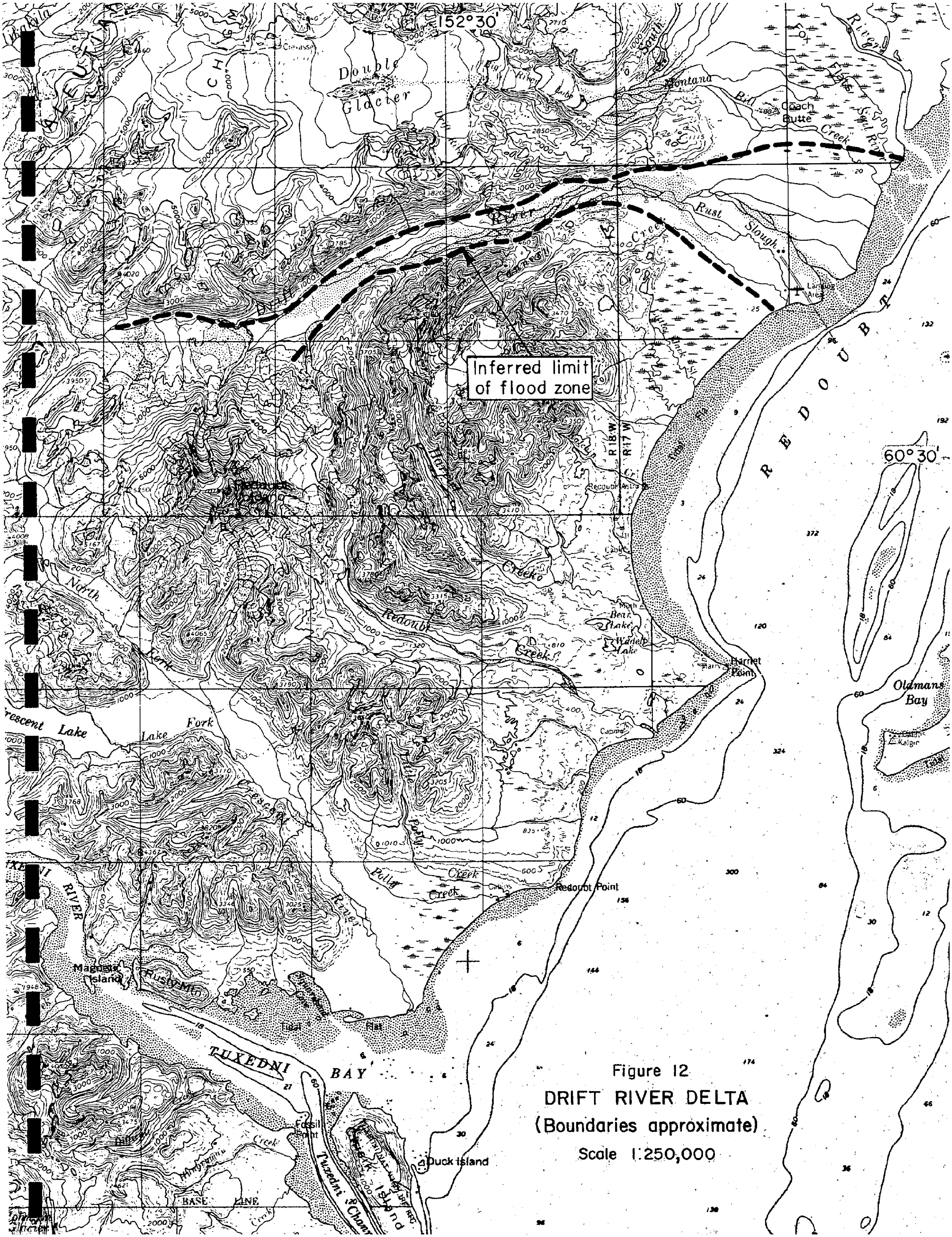


Figure 12
DRIFT RIVER DELTA
(Boundaries approximate)
Scale 1:250,000

Kodiak

A. Geographical Location

1. Region: Southcentral Alaska
2. Latitude: 57° 47' 20" N
   Longitude: 152° 47' 10" W
3. Additional Information: U.S. Geol. Survey Quad., Kodiak (C-1, C-2, D-1, D-2), scale 1:63,360.

B. Area Description

1. General geological setting: The town of Kodiak sits upon bedrock composed of marine sedimentary rocks of probably Cretaceous age which have been complexly deformed and intruded by granitic rocks. Surficial deposits are generally thin and discontinuous, although parts of the Women's Bay area are underlaid by thicker glacial or alluvial deposits and artifical fill. The area south of Kodiak to Ugak Bay consists of poorly consolidated upper Tertiary marine sedimentary rocks which have been gently to moderately folded and which overlie the older rocks. Most of the coast consists of rugged rocky bluffs.

2. Criteria employed in identification as an APC: Kodiak and the surrounding area suffered extensive property damage and 18 lives were lost as a result of a tsunami generated by the earthquake of March 27, 1964. There are no other reports of tsunamis striking the area in historical times. The runup level of the waves varied according to locality, topography of the offshore bottom and other factors. Maximum runup is some unihabited areas of the island was in excess of 15 m., and runup at the town of Kodiak was in excess of 6 m., causing extensive damage to the waterfront.

3. Reason for inclusion of this area as an APC: Kodiak is the focal point and economic hub for fishing, logging and cattle ranching activities for the area and surrounding islands. These industries constitute the economic base for the region. Kodiak Naval Station is located 10 km south of the city and provides substantial revenue to the area. Any interference with these activities could have an adverse effect on the Alaskan economy as a whole.

4. Other: The Army Corps of Engineers has identified the Shakmanof Cove, Kizhuyak Point area as being one of the few areas in the Kodiak Region which has suitable amounts of rock for use as any and all types of construction materials. Sound durable rock of all sizes could be quarried and excellent quarry operations could be developed with a minimum of effort. (G. Greely, pers. comm., 1977)
   Much of Kodiak Island is a National Wildlife Refuge.
   See figure 13.

Reference: Kachadoorian, R., and Plafker, G., 1967, Effects of the earthquake of March 27, 1964 on the communities of Kodiak and nearby islands, U.S. Geol. Survey Prof. Paper 542-F, p. F1-F41.

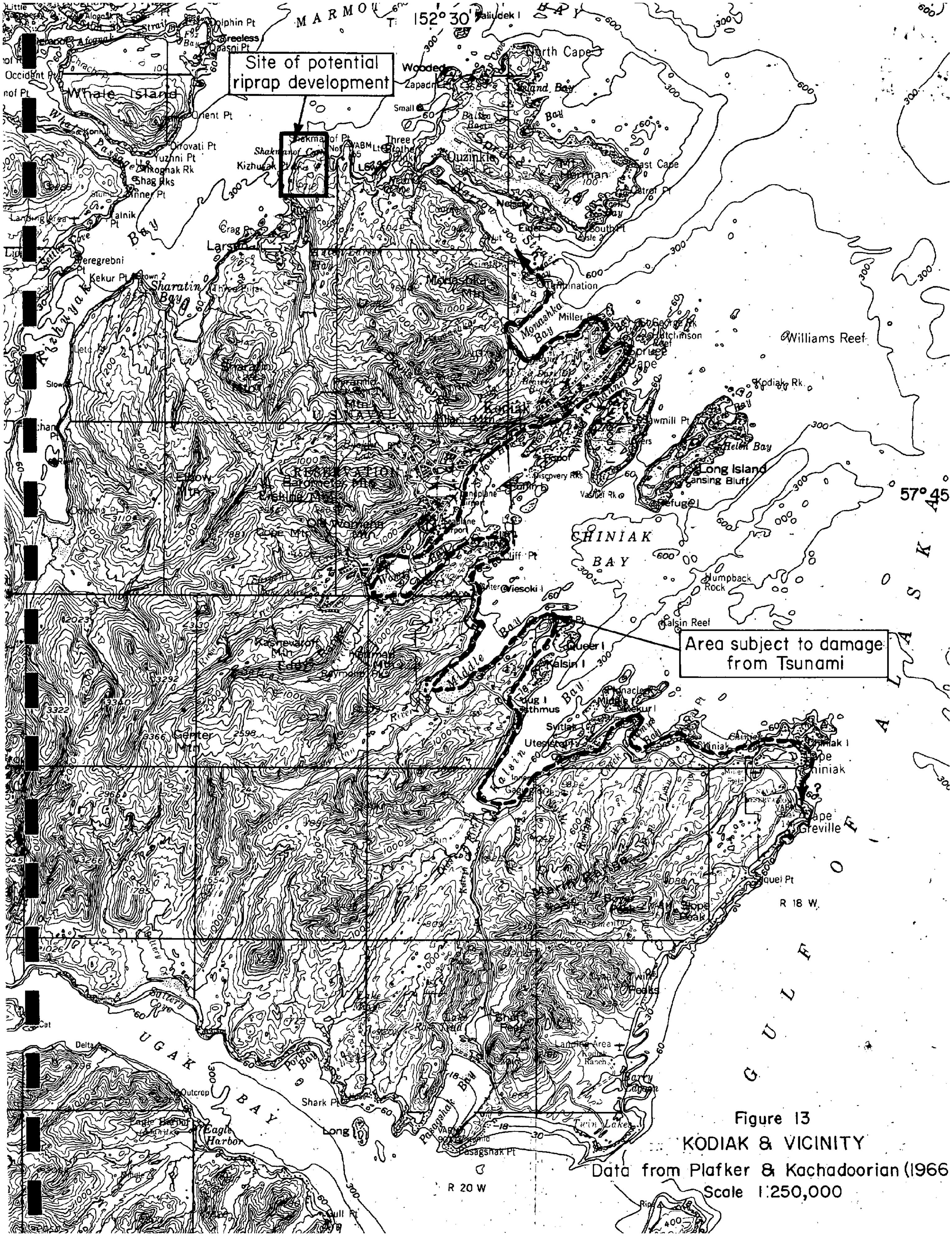


Figure 13
KODIAK & VICINITY
Data from Plafker & Kachadoorian (1966
Scale 1:250,000

Scotch Cap, West End of Unimak Island

A. Geographical Location

1. Region: Aleutian Islands
2. Latitude: 54° 45' N
   Longitude: 165° 00' W
3. Additional Information: U.S. Geol. Survey Quad., Unimak, scale 1:63,360.

B. Area Description

1. General geological setting: The area of particular concern is located on the westernmost end of Unimak Island. The area to the north and east rises sharply from the coastline and culminates in Faris Peak 1600 m. Unimak Island is basically composed of Quaternary basaltic and andesitic lava flows and pyroclastic deposits. Both Westdahl and Pogromni are volcanos of recent origin.

2. Criteria employed in identification as an APC: The western end of Unimak Island has been hit at least twice in very recent times by tsunamis of considerable size. On April 1, 1946, a tsunami struck which demolished the Scotch Cap light house and killed five people. This wave was generated by a submarine earthquake of magnitude 7.4 located about 280 km to the southeast of the island. A runup of about 30 m. was recorded. Again on March 9, 1957, an earthquake of magnitude 8.3 occurred to the southeast. Although lighthouse personnel reported no damage occurred, a runup of 15 m. was estimated. This wave might have been generated locally by a marine landslide since its arrival was too early for a major tsunami.

3. Reason for inclusion of this area as an APC: Although the entire southern coast of Alaska is susceptible to tsunamis, only the areas of cultural activity where significant property damage or death have been recorded are designated as APC's. Thus, much of the Aleutian Islands coastline may be prone to damage by tsunamis. Only the areas where documented signigicant runups and where property damage has occurred or could occur are included here.

4. Other: The area is included in a National Wildlife Refuge. Also, Unimak Pass is a significant break in the Aleutian Island chain and might be important to shipping, in which case the maintenance of a lighthouse could be necessary. See figure 14.

Reference: Cox, D.C., and Pararas-Carayannis, G., 1976, (rev.), Catalog of tsunamis in Alaska, World Data Center for Solid Earth Geophysics, NOAA Report SE-1, p. 1-43.

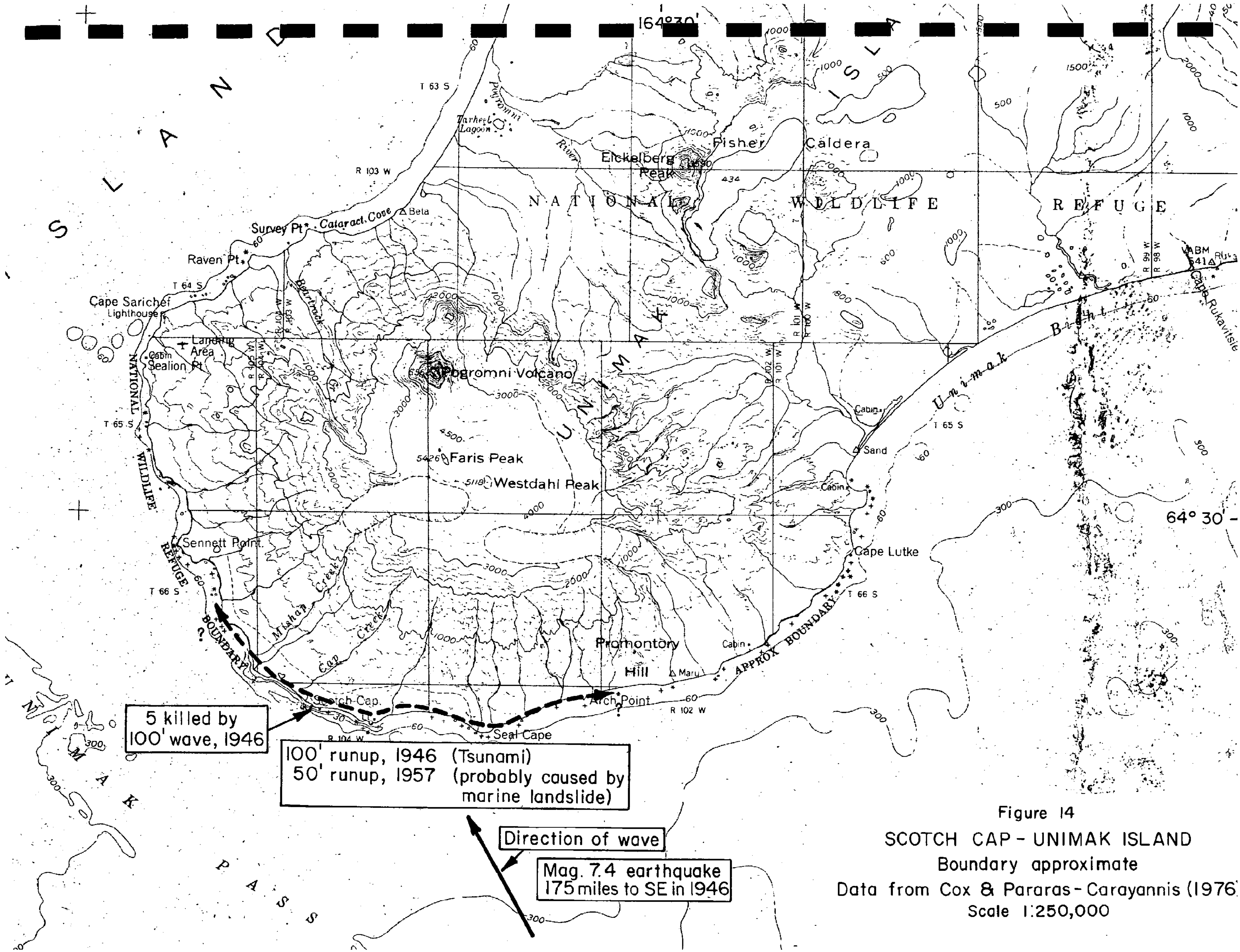


Figure 14
SCOTCH CAP - UNIMAK ISLAND
Boundary approximate
Data from Cox & Pararas-Carayannis (1976)
Scale 1:250,000

Shemya Island

A. Geographical Location

1. Region: Aleutian Islands
2. Latitude: 52° 43' 20" N
   Longitude: 174° 07' 00" E
3. Additional Information: U.S. Geol. Survey Quad., Attu, scale 1:250,000.

B. Area Description

1. General geologic setting: The area of particular concern is located 6 km east south east of Attu Island, on the westernmost extention of the Aleutian Island Chain. Shemya Island is the largest of the Semichi Islands. It has little relief. The island is composed of Tertiary or Cretaceous sedimentary rocks, including pyroclastic deposits, lava flows and minor pillow lavas.

2. Criteria employed in identification as an APC: Shemya Island has been hit by at least one tsunami in recent times. On Febuary 4, 1965 an earthquake of magnitude 7.8 occurred about 360 km. east south east, causing waves of about 10 m. to strike the island. The only reported damage was flooding to a warehouse.

3. Reason for inclusion of this area as an APC: Although the tsunami of 1965 did not cause considerable damage, tsunamis may well strike in the future. The USAF has established a base on the island, and there is a corresponding higher density of personnel and property on Shemya Island than in other areas in the Aleutians. Thus, the potential for property damage or loss of life there in the event of a major tsunami does exist.

4. Other: As previously mentioned, Shemya Island is presently being used as an air base by the USAF.
   See figure 15.

Reference: Cox, D.C., and Pararas-Carayannis, G., 1976, (rev.), Catalog of tsunamis in Alaska, World Data Center for Solid Earth Geophysics, NOAA Report SE-1, p. 1-43.

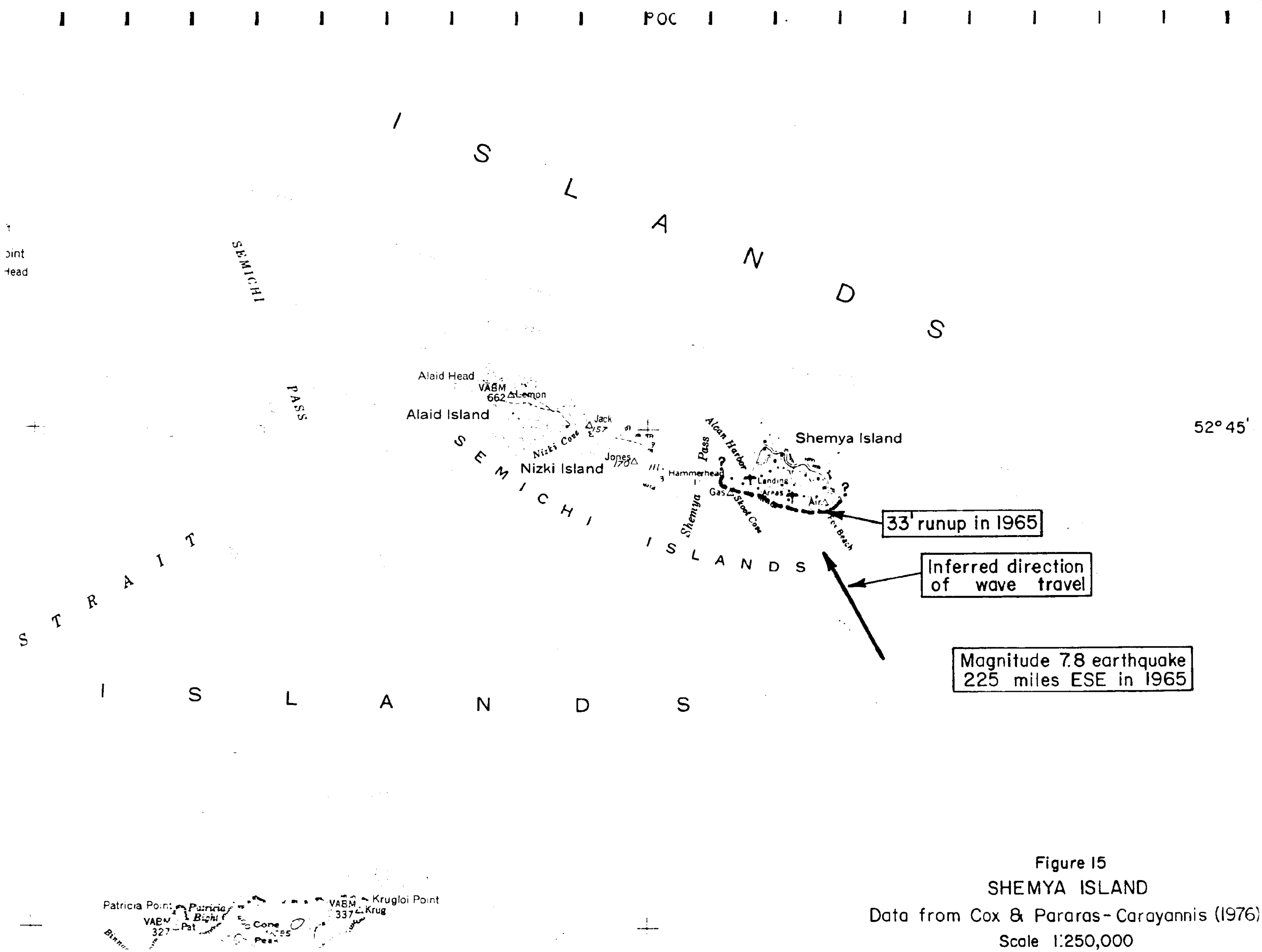


Figure 15
SHEMYA ISLAND
Data from Cox & Pararas-Carayannis (1976)
Scale 1:250,000

Pribilof Islands (St. George and St. Paul)

A. Geographical Location

1. Region: Southwestern Alaska, Bering Sea
2. Latitude: 57° N
   Longitude: 170° W
3. Additional Information: U.S. Geol. Survey Quad., Pribilof Islands, scale 1:250,000

B. Area Description

1. General geologic setting: St. George Island is composed of volcanic rocks (lavas) erupted mainly between 2.5 and 1.0 million years ago. St. Paul Island is mainly lavas erupted in the past 300,000 years. Both islands are extensively coverd by wind-blown silts and sands, partly stabilized by vegetation. St. George Island has been glaciated, St. Paul Island has not.

2. Criteria employed in identification as an APC: The islands have experienced volcanic eruptions as recently as 10,000 years ago (St. Paul Island), and faults disrupt relatively young volcanic rocks there. Consequently, the islands must be considered to pose hazards to any potential onshore and offshore developments, due to (a) direct contact with lava, bombs, or ash, or secondary slides, and locally generated tsunamis, in the event of renewed volcanic activity, and (b) seismic shaking, tsunamis, and ground breakage along faults which may move in future earthquakes.

3. Reason for inclusion of this area as a APC: Sedimentary basins of the Bering Sea are thought to have considerable oil/gas potential. A federal lease sale in the Bering Sea is now scheduled for December of 1981. The Pribilofs are logical candidates for siting of logistic bases, and for location of a pipeline terminal in the event that producible hydrocarbons are found.

4. Other: The Pribilofs presently constitute a federal game preserve. See figure 16.

5. Source of Data: Hopkins, 1976, Fault history of the Pribilof Islands and its relevance to bottom stability in the St. George Basin: Alaskan OCS Principal Investigators' Annual Reports, NOAA/BLM, p. 41-67.

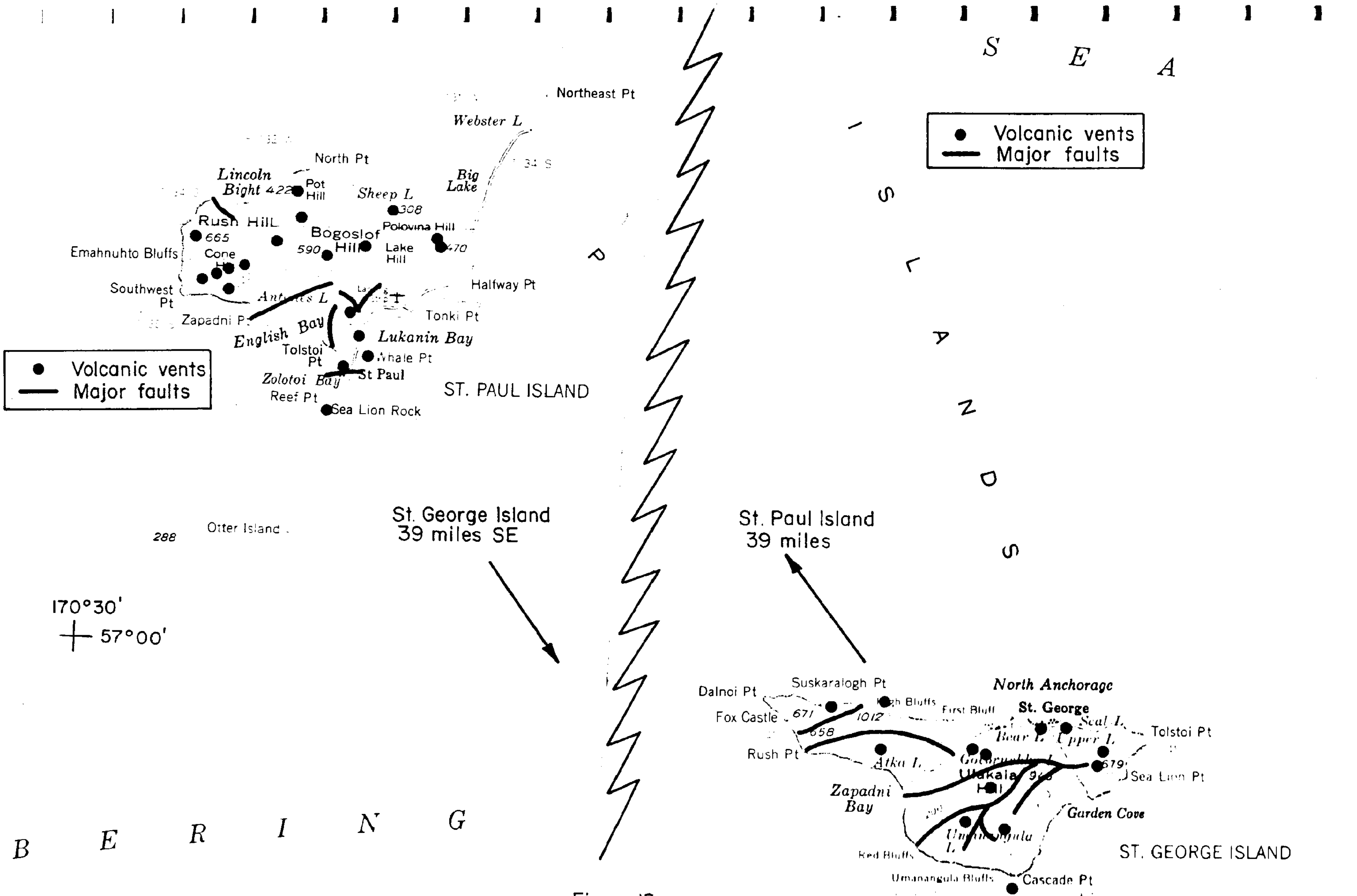


Figure 16
PRIBILOF ISLANDS
Data from Hopkins (1976)
Potentially active faults & volcanic vents
Scale 1:250,000

Cape Krusenstern to Cape Thompson

A. Geographical Location

1. Region: Western Alaska, Chukchi Sea
2. Latitude: 67° 5' to 68° 10' N.
   Longitude: 163° 30' to 166° W.
3. Additional Information: U.S. Geol. Survey Quad., Noatak, Point Hope, scale 1:250,000.

Area Description

1. General geologic setting: Cape Krusenstern is an accreted beach-ridge plain which separates Krusenstern Lagoon from waters of Kotzebue Sound. Much of the sand and gravel comprising the plain has been carried from a northern source, possibly as far as Cape Thompson (105 km). The oldest ridges formed at least 3500 years ago, and possibly as much as 4500 years ago (ages are inferred from archeological evidence and from morphology and elevations of the ridges). The shore between Cape Krusenstern and Cape Thompson consists chiefly of barrier bars backed by lagoons. Erosional bluffs are cut in bedrock or gravel (Cape Thompson to Kisimilok Mountain, and at Battle Rock) and in silt and sand (locally between Rabbit Creek and Krusenstern Lagoon). Elsewhere, the coast is low-lying and devoid of bluffs.

2. Criteria employed in identification as an APC: Detailed work by the U.S.G.S. at Cape Krusenstern shows that the beach ridge plain has experienced short periods of erosion at various times throughout the 4500-year period of net accretion. Such erosion might have been caused by shifts in the direction of storm winds, or by interruptions in the supply of sediment. Available evidence suggests that much of the sand and gravel of which the plain is constructed was delivered by littoral drift from sources as far to the northwest as Cape Thompson. Consequently, coastal activies and construction (such as jetties) between Cape Krusenstern and Cape Thompson could interrupt the littoral drift to the extent of causing erosion at Cape Krusenstern.

3. Reason for inclusion of this area as an APC: The Cape Krusenstern beach ridge plain has been occupied nearly continuously for the past 4500 years and constitutes a record of Arctic archaeology of major importance.

4. Other: The area is proposed for classification as a National Monument. See figure 17.

Reference: Hopkins, D.M., 1977, Coastal processes and coastal erosional hazards to the Cape Krunsenstern archaeological site; U.S. Geol. Survey Open-file Report 77-32 , p. 15.

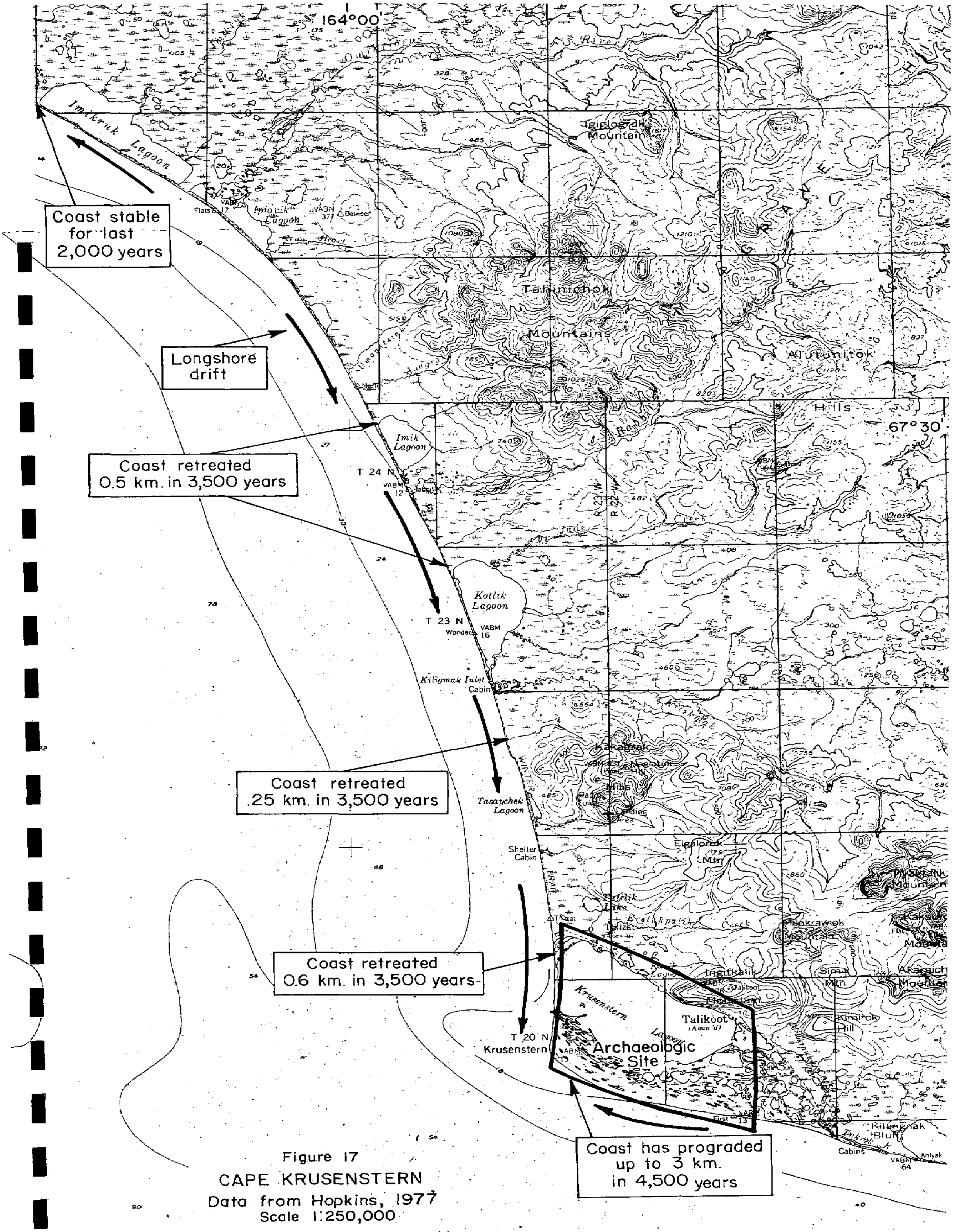


Figure 17
CAPE KRUSENSTERN
Data from Hopkins, 1977
Scale 1:250,000

Wainwright and Barrow and Vicinity

A. Geographic Location

1. Region: Northern Alaska, Chukchi Sea
2. Latitude: 70° 40' N
   Longitude: 160° W
3. Additional Information: U.S. Geol. Survey Quad., Wainwright (C-2), Barrow (B-4), scale 1:63,360.

B. Area Description

1. General geologic setting: The land surface in the APC is part of the Arctic tundra plain. Frozen permafrost is present nearly everywhere at shallow depths on land, and probably occurs beneath the sea bottom to some distance offshore. Deposits at or near the surface are older interbedded marine and terrestrial sands and gravels, and beach deposits along the present shoreline.

2. Criteria employed in identification as an APC: The entire coastline from Icy Cape to the Canadian border is recognized as one of relatively high rates of bluff retreat by thermal erosion and wavecut. Coastlines are retreating faster in this area than in most parts of the Chukchi Sea coastline. Erosion occur chiefly during the late summer and fall storm surges, when winds and air pressure cells can combine to raise sea level above mean higher high waterline. Such a storm surge in 1975 was responsible for flooding from Icy Cape to Peard Bay; the inundation locally was the greatest recorded in this century. In addition to erosion and storm surge flooding, the coastline from Icy Cape to the Canadian border is thought to be underlain by bonded permafrost at shallow depths beneath the seafloor, from the beach out to water depths estimated to range from 2m to 30m. Bonded permafrost was not found beneath the bottom of Elson Lagoon at Barrow, but preliminary work suggests that permafrost is likely to be present beneath parts of Wainwright Inlet.

3. Reason for inclusion as an APC: Wainwright and Barrow are the largest coastal communities within Naval Petroleum Reserve A. Should producible hydrocarbons be found in the reserve, then either or both villages could be considered as potential sites for logistical bases or even storage depots. Coastal erosion flooding and permafrost are obvious constraints to be considered in development of facilities at the coastline.

4. Other: NOAA/BLM sponsored research is continuing in the Chukchi-Beaufort coastal area, and more definitive publications should be available by 1978 or 1979. See figures 18 (Wainwright) and 19 (Barrow).

Reference: Hopkins, D.M., 1976, Shoreline history of the Chukchi Sea as an aid to predicting offshore permafrost conditions; Alaskan OCS Principal Investigators' Reports, NOAA/BLM (July-September 1976), p. 213-218.

Rogers, J.C., Gedney, L.D., Shapiro, L.H., and VanWormer, D., 1975, Near shore permafrost in the vicinity of Point Barrow, Alaska; Proceedings of the Third International Conference on Port and Ocean Engineering under Arctic Conditions, Univ. of Alaska, Fairbanks, p. 1071-1082.

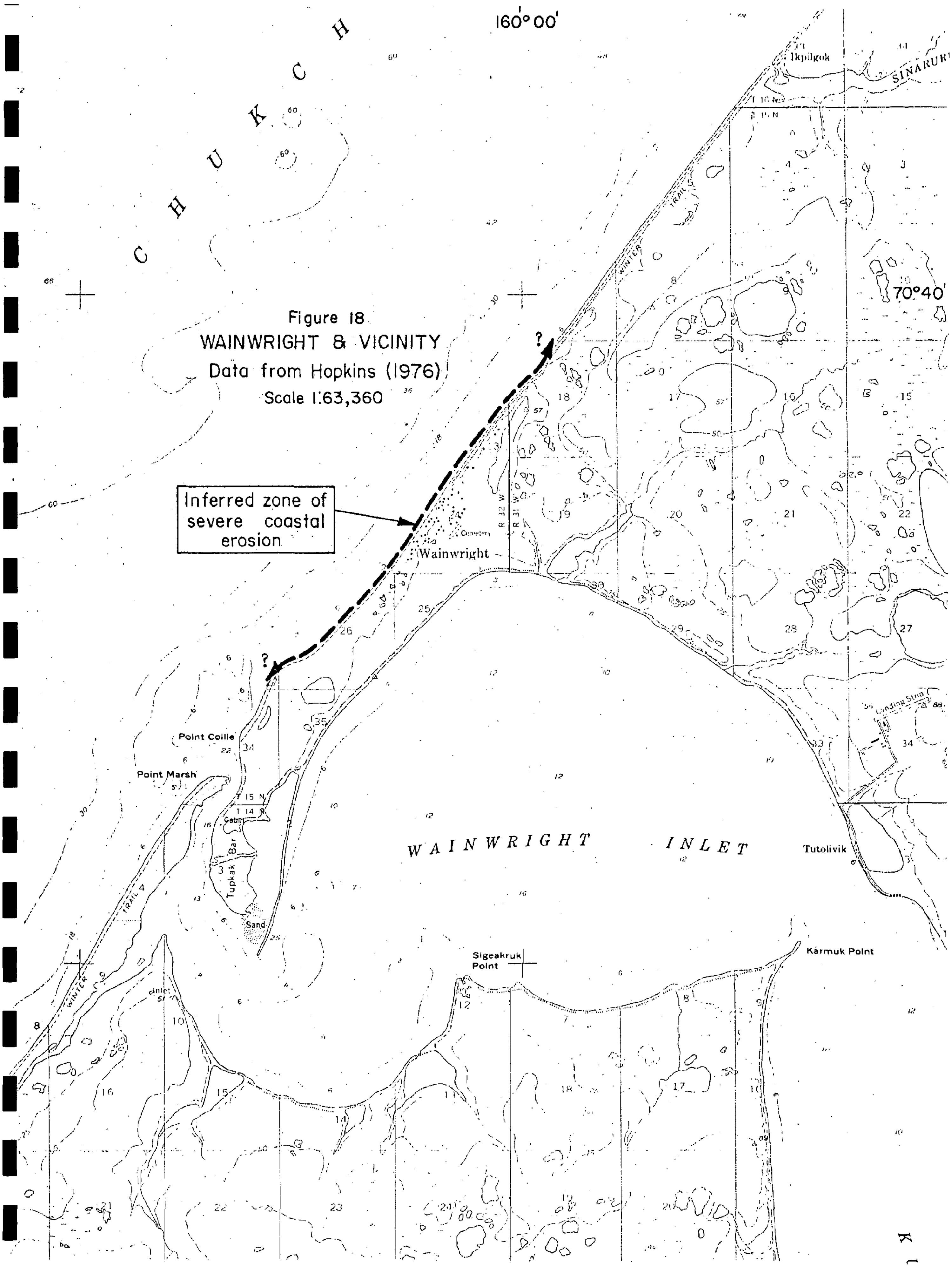
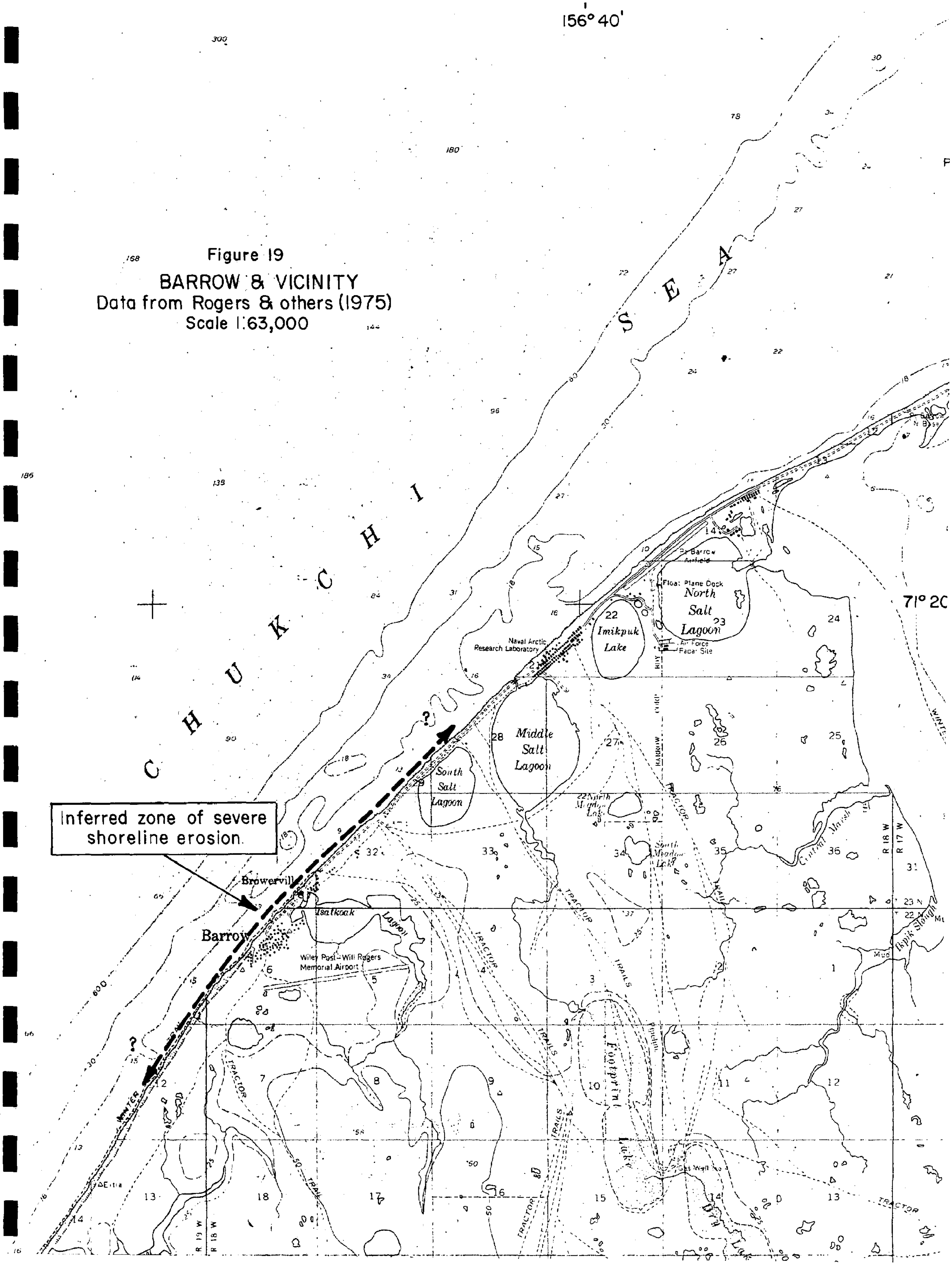


Figure 18
WAINWRIGHT & VICINITY
Data from Hopkins (1976)
Scale 1:63,360


156° 40'
Figure 19
BARROW & VICINITY
Data from Rogers & others (1975)
Scale 1:63,000
CHUKCHI SEA
71° 20
Inferred zone of severe shoreline erosion.
Browerville
Barrow
Isatkoak Lagoon
Wiley Post - Will Rogers Memorial Airport
South Salt Lagoon
Middle Salt Lagoon
Imikpuk Lake
North Salt Lagoon
Naval Arctic Research Laboratory
Float Plane Dock
Pt Barrow Airfield
Air Force Radar Site
North Meadow Lake
South Meadow Lake
Footprint Lake
Dry Lake
Central Marsh
Gas Well No 3
TRACTOR
TRAILS
R 19 W
R 18 W
R 17 W
23 N
22 N

Prudhoe Bay and Vicinity

A. Geographic Location

1. Region: Northern Alaska, Beaufort Sea
2. Latitude: 70° 20' N
   Longitude: 148° 25' W
3. Additional Information: U.S. Geol. Survey Quad., Beechey Point (B-4), scale 1:63,360.

B. Area Description

1. General geologic setting: The land surface around Prudhoe Bay is part of the North Slope tundra plain. Interbedded marine and alluvial sands and gravels underlie the area. Organic matter (tundra), active river courses, and active and stabilized wind dunes comprise the majority of the land surface features. Lake basins which have originated by thawing of the ubiquitous permafrost comprise the remaining features. Up to 2 meters of sea ice freezes annually offshore of the area ("fast ice").

2. Criteria employed in identification as an APC: The location of the channel followed by barge tugs into Prudhoe Bay (and now to the gravel causeway constructed by ARCO in 1975) has shifted relative to shoreline by as much as 175m between 1950 and 1976. Mean depth of the channel (minimum depths entering Prudhoe Bay were between 1 and 2 m. in 1976) may have increased slightly. However, shoaling of the channel is reported during the open water season (July to September). Nearby, Stump Island has also shifted southwest ward (relatively shoreward) and grown in area. Exposed shoreline from Point McIntyre east has been eroded (primarily thermal erosion of permafrost tundra) at an average rate of 1 m/yr., but locally by as much as 3 m/yr., during the period 1950 to 1970.

   Furthermore, the offshore area in and around Prudhoe Bay is everywhere thought to be underlain by ground below 0°C. Ice-bonded permafrost is thought to occur just below the sea-bottom in areas contacted by annual sea ice (that is, less the 2m depths) and at progressively greater depths further seaward of the 2m isobath. Overice flooding and spring breakups on the larger rivers (such as the Sagavanirktok) are potential hazards, but no final studies have yet been published on specific rivers within this APC.

3. Reason for inclusion of this area as an APC: Petroleum activity in the vicinity of Prudhoe Bay is intense. Freight barges used the bay entrance channel almost exclusively for the past 8 years, and now make heavy use of the ARCO causeway for offloading. The short open water season (normally July through September) and expense of constructing offloading and storage facilities, imply that changes in channel configurations and temporary interruptions in barge access can have serious consequences. It has been suggested that the Prudhoe Bay entrance channel is scoured by sub-ice currents during freeze-up, and begins to infill during open water. Thus, the channel may not be irreversibly filling up, at least in the foreseeable future. Future coastal activities anywhere in the Beaufort Sea must allow for shoreline erosion and natural changes in offshore bathymetry as well as potentially adverse effects of the activities themselves on the rates of such changes. Also, engineering design and construction must allow for potentially adverse effects of melting (bonded) permafrost, especially settlement and subsequent material-erosion, both onshore and offshore.

4. Other: See figure 20.

References: Barnes, P., Reimnitz, E., Smith, G., and Melchior, J., 1977, Bathymetric and shoreline changes, northwestern Prudhoe Bay, Alaska; U.S. Geol. Survey Open-file Report 77-161.

Osterkamp, T.E., and Harrison, W.D., 1976, Subsea permafrost at Prudhoe Bay, Alaska; drilling report: Univ. Alaska Geophys. Inst., Sea Grant Report No. 76-5.

Hopkins, D.M., 1976, Offshore permafrost studies, Beaufort Sea; Alaskan OCS Principal Investigators' Reports, (July-September, 1976), NOAA/BLM, p. 83-100.

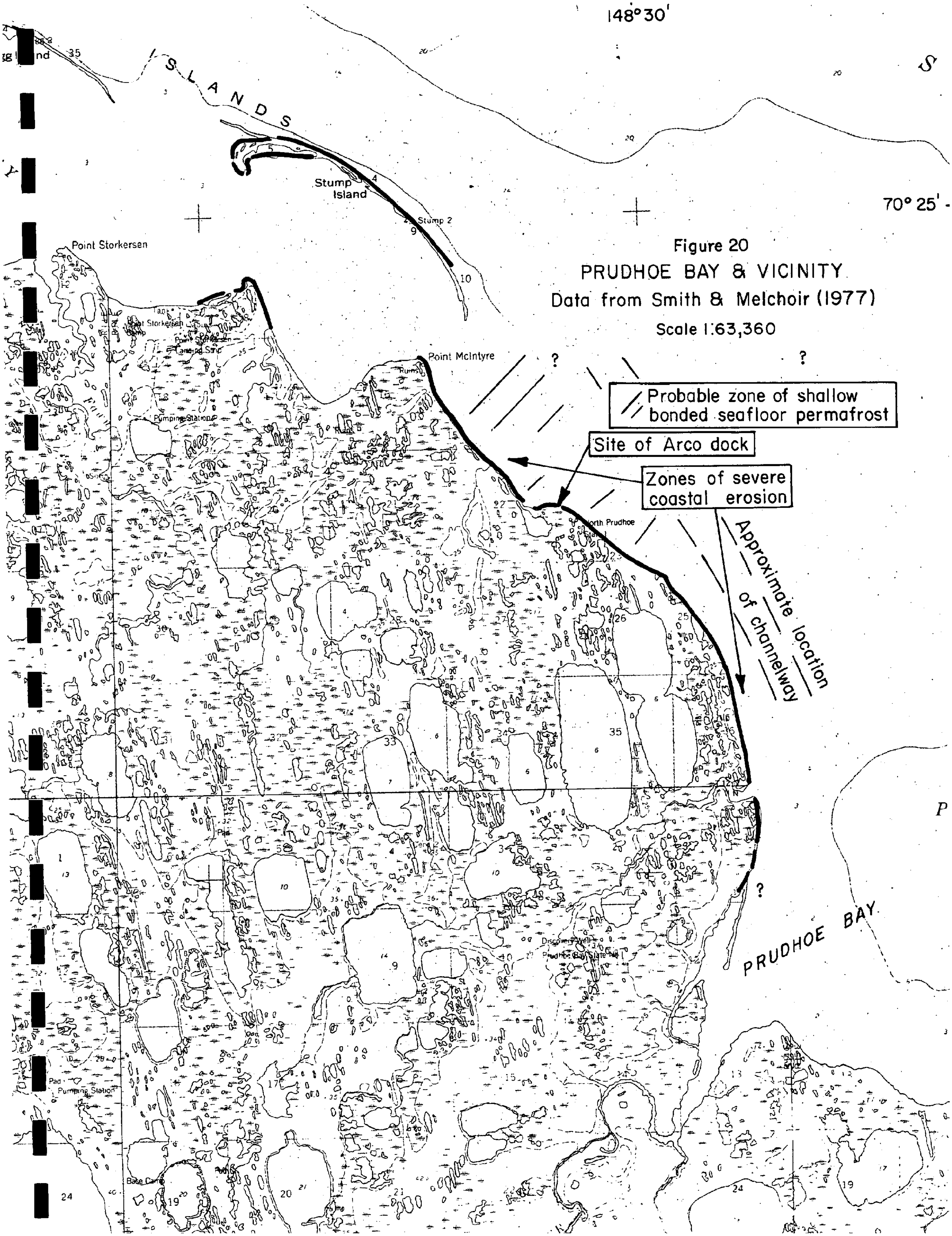


Figure 20
PRUDHOE BAY & VICINITY
Data from Smith & Melchoir (1977)
Scale 1:63,360